27
1287
8841A

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 41 20 FEBRUARY 1960 NO. 1

THE STATUS AND DISTRIBUTION OF FISHER IN MAINE

BY MALCOLM W. COULTER

The purpose of this report is to summarize details of a recent increase of fisher, *Martes p. pennanti*, in Maine. Information has been gathered from a variety of sources including winter field studies since 1950, examination of 177 specimens at the laboratory, more than 300 records of both legal and illegal or accidental catches, numerous contacts with trappers, and data furnished by State game wardens and regional game biologists of the Department of Inland Fisheries and Game.

Allen (1942) presented an excellent summary of the status of the fisher throughout its range. A more recent discussion of distribution has been published by Hagmeier (1956). In the northeastern states and the Maritime Provinces of Canada the species had disappeared from much of its former range by 1930. Small numbers persisted in the more remote regions of the Province of New Brunswick and in the States of Maine, New Hampshire, Vermont and New York. Smith (1940) reported that the species was probably extinct in Nova Scotia. However, several animals were released in that Province in 1948 (Benson, 1959). Capture of young animals since 1955 suggests that these releases were successful.

Following several years of protection in the northeastern states, an encouraging, but slow, increase in numbers of fisher began to be noted in some sections during the 1940's. This population recovery soon gained momentum and by the period 1950–1955 the species had spread from its remote retreats to occupy surrounding habitat in New York (Hamilton and Cook, 1955), New Hampshire (Hamilton, 1957; Silver, 1957), and in Maine. A similar, but apparently less noticeable trend has also become evident in New Brunswick (Bruce S. Wright, *in litt.*). Wright states that during the period 1949–1954 the species extended its range southward as far as the valleys of the Keswick and the Nashwaak rivers in York County in southern New Brunswick. In Maine, the range of the fisher has almost doubled during a period of eight years. It is now found in an area of approximately 23,000 square miles (73 per cent of the State).

Details about the early status of the fisher in Maine are vague and sometimes conflicting. The animal is mentioned in several writings during the 1800's, but it is not possible to piece together a detailed picture of the status of fisher

from these reports. The information presented does indicate that fisher were generally distributed over the northern and northwestern two-thirds of the State, but were not abundant in comparison with other fur animals, such as the marten. This is suggested from catch records or general information in several writings, but is more clearly summarized by Hardy (1907). Based upon his trapping and fur-buying activities, dating to about 1850, he wrote: "The proportion of sable to fisher varies greatly according to the ground hunted on. In some cases a large catch of sable will be made and not a fisher be taken; in other places several fisher will be taken and no sable, but usually a hunt of from fifty to a hundred sable will have from three to five fisher."

Although several naturalists and trappers published material concerning mammals in Maine up until the early 1900's, there is a scarcity of information after that period. But, from discussions with several elderly men who were active trappers from about 1900 to 1935, it is apparent that the fisher continued to be found sparingly and that it was avidly sought for its valuable pelt. Trappers were active in the wilderness region of Maine during that period. Furthermore, it was common practice for some men at lumber camps to set a few traps near their camps. These were tended enroute to and from lumber operations or, as was the more common practice, tended on Sundays. With fur generally high and fisher pelts at times selling for $100.00 or more each, some individuals returned from a winter's logging with more money from fur than they earned cutting wood. It appears that the species was relentlessly pursued by any who were aware of its presence.

By the mid-thirties fisher had become uncommon in most areas. Fortunately, at about this time, recognition of its unfavorable status resulted in an abrupt change in the law governing trapping. The State Legislature declared a closed season effective 1 July 1937. Prior to that date it had been legal to take fisher for periods as long as three months in some parts of the State!

The first indication of the state-wide status of the species in Maine resulted from a questionnaire sent to all State game wardens in 1939 (Aldous and Mendall, 1941). Approximately 90 wardens were contacted and asked to rate the status (abundant, common, rare) of various animals in their districts. Their results were rechecked by their division supervisors. Although the ratings employed are subjective, the results seem significant with respect to fisher because of the unanimity of the opinions expressed. *All but two men reported that fisher were rare or absent in their areas.*

Although there is no specific information to illustrate a general increase of fisher in Maine during the early 1940's, the animals were known to be common in some localities. Marston (1942) considered that fisher were common in parts of Jerusalem Township, Franklin County. Because of his winter field studies of the relationship between bobcat and deer, Marston was well acquainted with that area. It includes some of the highest mountains in the State and, at the time of his study, parts of the area were rather inaccessible and contained several stands of virgin spruce.

At Baxter State Park (which includes Mt. Katahdin), Dyer (1948) found fisher abundant. On the original 90,000 acres of the park, all wildlife had been protected since 1923. After his intensive winter cruises in 1941 and 1942, Dyer wrote, "The winter surveys indicated a good population of fisher . . . on the sanctuary as compared to the State as a whole.

"Fisher tracks were recorded 24 times with 6 fisher tallied in the Sourdnahunk District, or about one or two animals to a 36 square mile township. In the Wassataquoik District 18 fisher were tallied, or about six to a township."

Undoubtedly the animals were also common in other scattered localities in the more remote regions during the late thirties and the early and mid-forties. However, it was not until after World War II when, perhaps because of renewed human activity in the wilderness areas, a very definite increase in fisher numbers began to be noticed by State game wardens, trappers, biologists, timber cruisers and others who had occasion to be out-of-doors. From 1946–1949, 43 animals, accidentally caught, were turned in, as required by law, to the Department of Inland Fisheries and Game. Several more were reported to have "footed" and escaped from traps and, of course, it is likely that others caught were never reported. Some of these animals came from places where fisher had not been commonly found in the preceding few years.

These general reports of an increase of fisher were substantiated by the results of another questionnaire sent to all State game wardens in 1949 (Coulter, 1952). This inquiry was similar to that made 10 years earlier, except that instead of approximately 90 wardens, the force in 1949 consisted of 124 men. *Every man in northern and western Maine reported that fisher were either common or abundant—10 years earlier in the same area all but two men reported fisher rare or absent.*

It is important to note that all indications of the increase in fisher came from a fairly distinct physiographic division of Maine known as the Moosehead Plateau as described by Toppan (1935). This region is differentiated from other parts of the State by its higher elevation (average of over 1,000 feet), numerous mountains up to about 4,000–5,000 feet, lack of settlement and the presence of a vast, spruce–fir–northern hardwood forest. Ten years ago much of the area was roadless, except for more or less temporary roads used in lumber and pulpwood operations.

Further evidence of the recovery of fisher, and of their distribution, resulted from a legal trapping season during January 1950—the first such season in 14 years. No catch limit was imposed; trapping was permitted state-wide for an entire month. Fortunately, the law did stipulate that each pelt must be tagged by the Department of Inland Fisheries and Game before the skin could be sold. Thus, a record of the number and approximate locality of fisher taken was made possible. The distribution of the 124 animals caught is plotted in Fig. 1.

Several interesting aspects of the distribution of the catch and of trapping activity may be summarized as follows:

1. Although trapping was permitted state-wide, almost all catches came from the Moosehead Plateau region, or along the immediate periphery of this area.

2. Few persons made a special effort to trap fisher. For the most part, the animals were trapped incidental to activity along trap lines established for beaver, or by bounty trappers who were trapping for bobcats.

3. Bounty trappers were active throughout most of the State. During the calendar year 1950, 549 bobcats (taken from all but five small coastal counties) were presented for bounty. As discussed later, fisher are readily taken in sets intended for bobcats.

4. Trapping pressure for beaver was heavy state-wide. Although all waterways were not open to trapping, those that were declared open were distributed throughout the State. Although there is little relationship between the distribution of fisher and that of beaver, the fact that trappers were active statewide during the winter is of importance.

5. All persons concerned with the trapping season agreed that trapping pressure for fisher had been very light. Many of the trappers stated or wrote that they could easily have taken many more fisher if they had established trap lines for this animal. However, the pelts were not selling for attractive prices and it was more profitable for the men to devote their efforts to beaver—an animal with which they also had considerable experience. They trapped fisher (and bobcats for bounty) wherever it was convenient to do so along the routes traveled when operating the beaver trap line.

From the above it seems logical to assume that had numbers of fisher been present in areas distant from the Moosehead Plateau, some of them would have been taken by trappers.

Thus, by 1950, after 13 years of protection, the fisher had made a remarkable recovery in the highland region of northern and northwestern Maine. Ten or 12 years previously it was sparsely distributed in the region, with a few isolated locales likely containing fair numbers of animals.

Since 1950 the species has not only continued to increase in numbers, but also to expand into other parts of Maine. Some of the details of this expansion are illustrated in Fig. 1. Actual specimen records were used for the most part in presenting this material. I have included some records based upon tracks, but only where I have had the opportunity to verify the track reports. Numerous reports of the appearance of fisher in new areas have proved false upon careful investigation. While the track pattern made by the fisher is rather distinctive, other animals do at times make a somewhat similar pattern. For this reason track records must be critically investigated before one can accept them as evidence of the presence of fisher.

There are several significant aspects of the dispersal of the fisher into new areas:

1. The range in 1950 was largely restricted to a semiwilderness highland plateau, consisting of approximately 13,000 square miles. Fisher were never extirpated from this region.

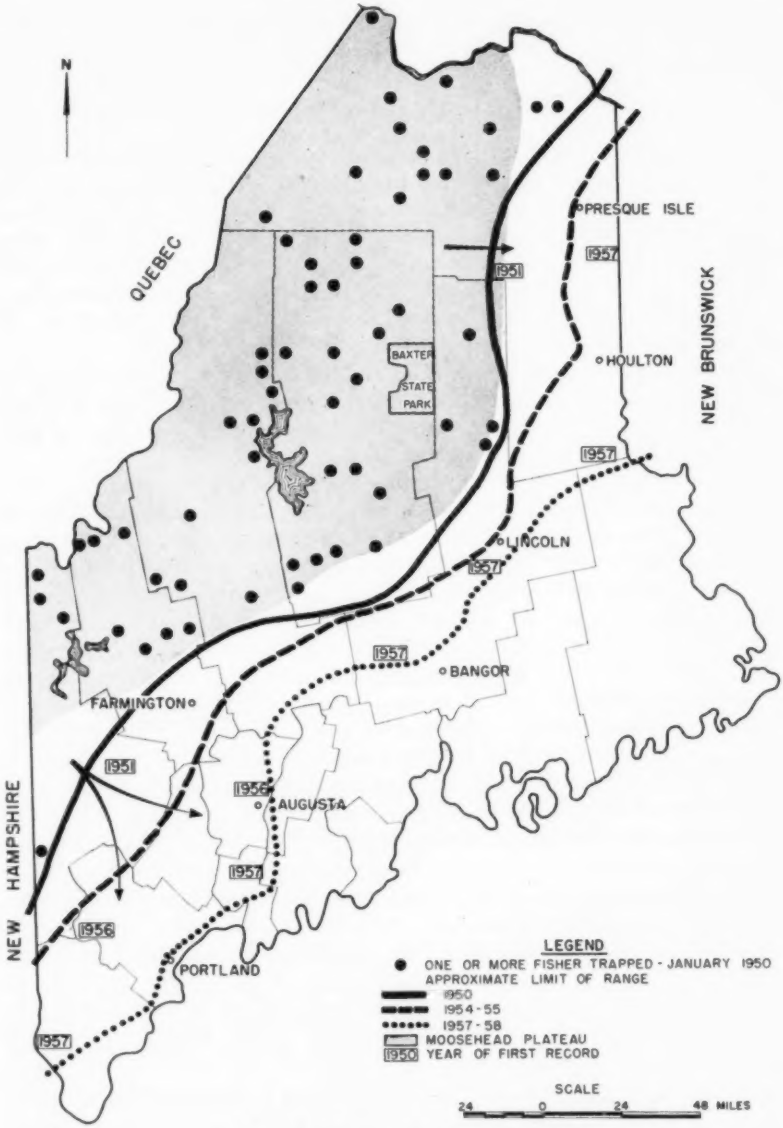


FIG. 1.—Distribution of fisher, 1950–1958.

2. Evidence of the presence of fisher in several places south and east of the Moosehead Plateau was obtained during 1951–1953. By the winter of 1954–1955, the animals had dispersed into approximately 4,800 square miles of previously unoccupied habitat. Parts of this area consist of predominantly second-growth hardwood forest.

3. During the following three years the range expanded south and east from the highland region to include an additional 5,400 square miles. By 1957 the species had penetrated south to the coast in some places. This additional range includes many areas of reverting farmlands and second-growth woodlands interspersed with farms and villages.

4. The direction and speed of dispersal has shown a definite relationship to topography. Dispersal has occurred first and has been most rapid in hilly country, regardless of the kind of forest cover present.

5. Areas of low-lying coniferous forest containing a high proportion of bog or generally soggy area (even though densely forested) have not been invaded rapidly. Where fisher have penetrated these areas, high resident populations have not become established.

6. The largest block of potential fisher range in Maine is partially separated from the occupied range by a 15–40-mile-wide belt of comparatively flat, soggy, heavily forested woodland. Even within the block of unoccupied habitat, large marshy or soggy areas are more common, and precipitous terrain much less common than is the case in portions of the new range which have been occupied most rapidly.

7. During a period of seven years the range of the fisher expanded from an area of approximately 13,000 square miles to a total region of about 23,000 square miles. This represents a range expansion of about 75 per cent.

The density of populations, of course, varies greatly. It appears that numbers are still increasing in much of the more recently occupied sections. Intensive study of limited areas in good habitat has indicated populations of 8 to 10 animals per 36-square-mile township, or one animal per 3.6 to 4.5 square miles in some northern sections of the State.

Catches by trappers of from 4 to 6 fisher per township (or one animal per 6 to 9 square miles) have been made in several townships throughout the Moosehead Plateau. In the instances where it has been possible to check some of these areas after the trapping season, fisher sign was still abundant. It is expected that ranges vacated by the removal of one animal will soon be reoccupied by another. But it seems unlikely that harvests of 4 to 6 animals per township in periods of 25 days or less are possible without a generally high population in the area.

Hamilton and Cook (*op. cit.*) state that "There is surprising unanimity of opinion among experienced trappers that fisher populations throughout much of the Adirondack forest average about one fisher per square mile.

"Considering clearings and burns, there are approximately 6,000 square miles of suitable fisher habitat in the Adirondacks, and this area appears to be oc-

cupied, in varying degrees, by the species. We judge the present populations at between 3,000 and 4,000 individuals."

Because of the obvious variations in population densities in 23,240 square miles of present fisher range in Maine, I believe that it would be very misleading to attempt an estimate of the total population.

The chronology of the recovery of fisher in the various States of the Northeast is strikingly similar as illustrated by the following comparison:

	Maine	*New Hampshire*	*New York*
Populations very low, closed season established	1937	1935	1936
First indication of a population increase noted	Mid-1940's	Late 1940's or early 1950's	1940
Trapping season reopened	Jan. 1950	None	Nov. 1949
Evidence of fisher spreading into new areas	1951–1952	1951–1953	Late 1940's, early 1950's

One may well speculate about the reasons for this noticeable increase. In discussing this subject Hamilton and Cook (*op. cit.*) state that there is no evidence of cyclic behavior in New York. De Vos (1951) discusses cycles in fisher and states that, based upon fur returns for Ontario for the period 1920–1948, a strong peak occurred in 1928 and weak peaks in 1936 and 1947. There is no indication from the pattern of population increase in Maine to suggest noticeable cyclic behavior. Since the late 1940's the species has become progressively more numerous and has constantly expanded its range. However, it is possible that any cyclic tendency has been masked by the rapid increase in fisher numbers during the past 10 to 12 years and may become evident after the population has stabilized.

The pattern of recovery exhibited by the fisher strongly suggests that protection has been the most important contributing factor to its current improved status in the Northeast. We may summarize the evidence to support this hypothesis as follows:

1. The long period of drastic decline in populations prior to 1940 cannot be explained on the basis of possible cyclic behavior.

2. The species is very easy to trap and has a comparatively low reproductive rate.

3. Until protected it was subjected to intensive trapping pressure, especially in the more accessible parts of its northeastern range. The residual populations that persisted in Maine were largely restricted to the more inaccessible areas where trapping pressure was not as heavy as in other sections. Hamilton and Cook (*op. cit.*) stated that during the period when the animals were generally scarce in the Adirondacks, numbers did persist in areas removed from settlements. De Vos (1952) presents evidence to demonstrate that in Ontario, also, the density of fisher is greater in areas away from human settlement and states, "The species is practically absent from settled areas and has its main strong-

hold in refuges." A statement cited by Allen (1942: 178) concerning fisher numbers in the James Bay region suggests a similar relationship.

4. The recovery of fisher in Maine, New Hampshire and New York became noticeable within a few years after the species was protected in each area.

It appears that the fisher is a much more adaptable animal than has been generally believed. It is now thriving in habitat that a few years ago would have been considered unsuitable for it. Perhaps some of the concepts about the requirements of this species have developed because the only places where it did exist were the more remote, inaccessible areas. These too were the places where the forest was cut less often and thus consisted of older stands. Today the species is common in young forest stands that have followed repeated cutting, burns, or that are reverting from previous argicultural use. In the past the species has been so relentlessly pursued that it has been unable to survive in habitats readily accessible to humans.

Control of trapping should be exercised if the fisher is to continue to thrive in the Northeast. Under current conditions, trapping pressure does not seem excessive in Maine, largely because of the comparatively low value of raw furs. This situation, however, could change rapidly.

In addition to the influence of trapping for fisher, the effects of other kinds of trapping upon this species need to be more clearly recognized. Because the fisher readily seeks carrion and is not trap shy, it is often taken in baited sets intended for other animals. In Maine, men who trap bobcats for bounty take numbers of fisher. For example, during the period 1951–1958 a total of 170 fisher, taken accidentally (chiefly in sets for bobcats), was confiscated by the Department of Inland Fisheries and Game. Others so taken undoubtedly were left in the woods by trappers. Furthermore, because fisher struggle persistently when trapped, loss through footing is high. Our data for the January 1950 trapping season show that 124 animals were successfully captured, but trappers indicate that a minimum of 23 additional fisher escaped from their traps. Some of these animals survive, but others likely perish. I believe that this type of loss is greater when fisher are taken in sets intended for other animals, such as bobcats. Traps ordinarily used for bobcats are larger than those that should be used for fisher. The larger trap more often breaks leg bones and, hence, escape by the animal is merely a matter of time and endurance. Furthermore, breaks caused by larger traps frequently involve the upper leg bones. The loss of part or most of a leg is more serious than loss of toes or the foot. In areas where small populations of fisher are present, the loss caused by bounty trapping can be serious and no doubt is higher than the records of accidental catches indicate.

SUMMARY

By the 1930's the fisher was found in small numbers in parts of a wilderness area of Maine. The species was protected in 1937. By the mid-1940's an increase in numbers became apparent and by 1950 it was commonly found in a 13,000-square-mile semiwilderness region. During the period 1951–1957 it continued to increase in numbers and rapidly

expanded its range to include an additional 10,000 square miles of varied habitat. Areas of hilly terrain have been occupied more rapidly than sections of flat, low-lying woodland.

The recent history of the status of the species suggests that protection has been the most important factor responsible for its notable increase. Because it is easy to trap, has a low reproductive rate, and because its pelt is valuable, control of trapping (including the trapping of other animals for bounty) needs to be exercised if the fisher is to continue to thrive in the Northeast.

ACKNOWLEDGMENTS

I wish to thank the many State game wardens and biologists of the Maine Department of Inland Fisheries and Game as well as several trappers who have furnished specimens or information. All cannot be mentioned here, but special thanks are due to Biology Aide Myron Smart for his invaluable help with the field work, Chief Warden Elmer Ingraham for permitting me to handle animals taken by trappers accidentally or illegally, and biologists George Aiken, Robert Boettger, Henry Carson, Francis Dunn, the late Nathan Fellows, Jr., Kenneth Hodgdon, John Hunt and Howard Spencer, Jr., for submitting numbers of specimens, for field assistance in their regions, or for furnishing data. Thanks are also due former game technician Samuel Carney who assisted in gathering field data in 1950 under Federal Aid Project 28-R-1. I am indebted to Howard L. Mendall, Leader, Maine Cooperative Wildlife Research Unit, Ralph S. Palmer, New York State Museum, and William Miller, Vermont Fish and Game Service, for helpful suggestions and advice concerning the manuscript.

This is a contribution from the Maine Cooperative Wildlife Research Unit, Orono, Maine; Maine Department of Inland Fisheries and Game, University of Maine, Wildlife Management Institute, and the U.S. Fish and Wildlife Service cooperating.

LITERATURE CITED

ALDOUS, C. M. AND H. L. MENDALL. 1941. The status of big game and fur animals in Maine. Maine Coop. Wildl. Res. Unit. Mimeo., 24 pp. + maps.

ALLEN, GLOVER M. 1942. Extinct and vanishing mammals of the Western Hemisphere with the marine species of all oceans. Spec. Publ. No. 11, Amer. Comm. for Int'l. Wildl. Prot. 620 pp.

BENSON, D. A. 1959. The fisher in Nova Scotia. Jour. Mamm., 40: 451.

COULTER, MALCOLM W. 1952. Big game and fur-bearing animals of Maine. Maine Ext. Serv. Bull. 425. 32 pp.

DE VOS, ANTOON. 1951. Overflow and dispersal of marten and fisher from wildlife refuges. Jour. Wildl. Mgmt., 15: 164–175.

———. 1952. The ecology and management of fisher and marten in Ontario. Tech. Bull., Ontario Dept. of Lands and Forests. 90 pp.

DYER, HAROLD J. 1948. Preliminary plan for wildlife management on Baxter State Park. M.S. Thesis, Univ. of Maine, Orono. 80 pp.

HAGMEIER, EDWIN M. 1956. Distribution of marten and fisher in North America. Canad. Field Nat., 70: 149–168.

HAMILTON, GEORGE T. 1957. Resurgence of the fisher in New Hampshire. Appalachia, 23: 485–490.

HAMILTON, W. J., JR. AND ARTHUR H. COOK. 1955. Biology and management of the fisher in New York. N.Y. Fish and Game Jour., 2(1): 13–35.

HARDY, MANLY. 1907. The fisher. Forest and Stream, 68(18): 692–693.

MARSTON, MERWIN A. 1942. Winter behavior of deer in northwestern Maine. M.S. Thesis, Univ. of Maine, Orono. 53 pp.

SILVER, HELENETTE. 1957. A history of New Hampshire game and furbearers. Survey Rpt. No. 6, N. H. Fish and Game Dept., Concord. 466 pp.

SMITH, R. W. 1940. The land mammals of Nova Scotia. Amer. Midl. Nat., 40: 213–241.

TOPPAN, FREDERICK. 1935. Physiography of Maine. Jour. Geol., 43: 76–87.

Cooperative Wildlife Research Unit, Univ. of Maine, Orono. Received 25 June 1958.

THE TAXONOMIC STATUS OF *ANTROZOUS BUNKERI*

By Richard C. Morse and Bryan P. Glass

The population of bats of the genus *Antrozous* currently recognized as *A. bunkeri* Hibbard occupies a limited area in Kansas and Oklahoma, and is separated from its most nearly related form by 250 miles of territory seemingly unsuitable for its occupation. The taxonomic and philosophical problem posed by the existence of this disjunct population is the subject of this report.

Acknowledgment is extended to Viola S. Schantz (U.S. Fish and Wildlife Service), E. Raymond Hall (University of Kansas), Donald F. Hoffmeister (University of Illinois), Hugo Rodeck (University of Colorado), and P. F. Spangle (Carlsbad Caverns National Park) for arranging the loan of specimens used in this study. The Oklahoma specimens were all from the Oklahoma State University Museum of Zoology.

The population of *Antrozous*, heretofore referred to as *bunkeri*, is associated with outcrops of the Blaine Gypsum formation of Oklahoma and Kansas, where rocky bluffs and caverns provide the necessary habitat. A population of *Antrozous* also occurs in Cimarron County, Oklahoma. The problem dealt with in this report is concerned with the taxonomic relationship between these two populations, and the relationship of them both to *A. pallidus* from other parts of the southwestern United States.

Schwartz (1955) reasoned that geographic isolating mechanisms do not operate with the same force upon wide-ranging bats as they do upon more sedentary earth-bound mammals. He used this reasoning in support of his merger of several isolated nominal species of *Tadarida* into one polytypic species, *T. brasiliensis*. It would seem that the principle that permits unification of a population of *Tadarida* from the southeastern United States with one from Texas should apply to two related populations divided by the high plains of Texas and Oklahoma, provided that in other respects the relationships between them are of the order usually recognized as of only subspecific significance. It is from this viewpoint that these populations of the genus *Antrozous* have been examined.

To date, five forms of *Antrozous* have been described. The latest checklist (Miller and Kellogg, 1955) recognizes *bunkeri* from Kansas and *minor* from Baja California as full species, with the others subspecies of *A. pallidus*. *A. pallidus pallidus* is the form that most nearly approaches Oklahoma, being recorded from localities in New Mexico and Colorado. Burt (1952) and Orr (1954) both have speculated that *A. pallidus* and *A. bunkeri* might actually be conspecific. Krutzsch (1955), in his study of the bacula of various North American bats, found *bunkeri* and *pallidus* to be inseparable by this method. He further indicated that, in his opinion, the cranial and morphological differences between these forms were at best average ones, and that therefore *bunkeri* should be arranged as a subspecies of *pallidus*. The data presented here lend considerable statistical support to this viewpoint.

Antrozous bunkeri Hibbard (1934) was based on 25 specimens collected in Barber County, Kansas. A single specimen of *Antrozous*, collected in Cimarron County, Oklahoma by Blair (1939) and assigned by him to *A. pallidus pallidus*, constitutes the first Oklahoma record. Further collections were reported by Glass (1949, 1957) from the same area.

Prior to 1957, *A. bunkeri* had been recorded only from the vicinity of the type locality, except that Burt (1945) referred Blair's Cimarron County specimen to *A. bunkeri*. Twente (1955) banded eight *Antrozous* in Mays Cave, Barber County, Kansas during 1952–1953, and mentioned adjacent sites in the same county where the species had been observed. The first published record of *A. bunkeri* in western Oklahoma (exclusive of the Panhandle) is that of Glass (1957).

A total of 154 *Antrozous* from Oklahoma and Kansas were used in this study. All of those from Oklahoma, and most of those from Kansas, are catalogued in the Oklahoma State University Museum of Zoology. Additional specimens were borrowed from the Biological Survey Collections, U.S. National Museum (13); the Illinois Museum of Natural History (7); the University of Kansas Museum of Natural History (6); the University of Colorado Museum (2); and Carlsbad Caverns National Park (2).

Specimens that were collected from areas of close geographical proximity were grouped together for statistical treatment. This was considered justifi-

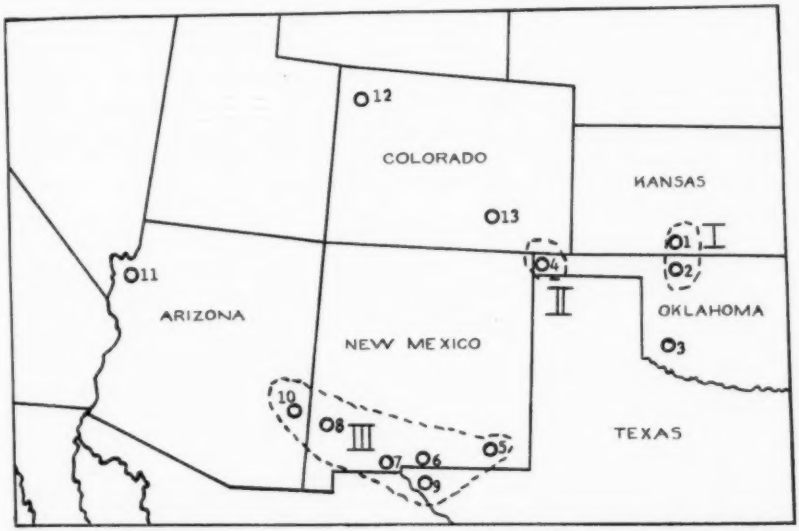


FIG. 1.—Collection sites of specimens of *Antrozous*: 1, Barber Co.; 2, Woodward Co.; 3, Greer Co.; 4, Cimarron Co.; 5, Eddy Co.; 6, Otero Co.; 7, Dona Ana Co.; 8, Grant Co.; 9, Hudspeth Co.; 10, Graham Co.; 11, Mojave Co.; 12, Moffatt Co.; 13, Otero Co. Roman numerals indicate groupings of specimens for statistical treatment.

able because of the mobility of bats. Most of the collection sites fall into three natural groups, which have been designated Groups I, II and III (Fig. 1).

The collecting sites for Group III are the most widely spread. However, they all lie within the heart of the range of *A. p. pallidus*, and the intervening spaces between them contained habitat suitable for the species. It has therefore been assumed that the sample used represents a single population within which gene flow is relatively uninterrupted.

Five specimens were examined that were not included in the groups. Three from Greer County, Oklahoma, could, on the basis of measurements, have been included in Group I. One each from Mojave County, Arizona, and Moffatt County, Colorado, could have been included in Group III.

Within each group the sexes were segregated and treated separately. Standard external measurements were taken from the collectors' original data. Forearm and skull measurements were made by the authors, using a dial caliper graded in tenths of a millimeter. In making color comparisons both Ridgway (1912) and Maerz and Paul (1930) were used.

Measurements which, when averaged, showed significant differences were total length, length of forearm, condylobasal length, and length of maxillary tooth row. To test the significance of the apparent differences between the samples, the means of the measurements of the three groups were calculated separately for each sex, the standard error for each sample was calculated, as well as the standard deviation. The results of these calculations have been graphically tabulated (Fig. 2).

To test further the significance of the apparent differences between the samples, the coefficient of difference between each of the samples as defined by Mayr, Linsley and Usinger (1953), was calculated for each character. According to these authors, the conventional level of subspecific difference, where the populations have overlapping characters, is where the *CD* value between them is 1.28 or higher. At this level there is 90 per cent joint nonoverlap between the two. *CD* values of less than 0.67 (75 per cent joint nonoverlap) are obviously of insignificant value in determining subspecific distinctness. The results of these calculations have been tabulated in Tables 1–3.

The means and standard errors derived from the measurements taken from

TABLE 1.—*Coefficient of difference values between Groups I and II*

MEASUREMENTS	MALES		FEMALES	
	CD value	Joint nonoverlap (%)	*CD* value	Joint nonoverlap (%)
Condylobasal length	1.16	88	1.22	89
Maxillary tooth row	0.94	83	0.70	76
Total body length	0.17	*	0.73	77
Forearm	0.11	*	0.31	*

* Less than 75 per cent joint nonoverlap.

the three population groups may be compared in Fig. 2. Using condylobasal length as the most useful character for distinction, Group I differs statistically from Group II and Group III in both sexes. A similar comparison between females of Groups II and III shows the difference between the means to be more than twice the sum of the standard errors, but not three times as great. The same value for males is less than twice the sum of the standard errors. Comparison of the other measurements between the two groups shows that the sums of the standard errors are less than twice as great as the difference between the means for both sexes. By the usual taxonomic standards, therefore, Group II does not differ statistically from Group III.

In color, *A. bunkeri* and *A. pallidus* are very similar. The collar in the nuchal region, as described by Hibbard (1934), is present in specimens of both populations. The same is true of the light area in the interscapular region.

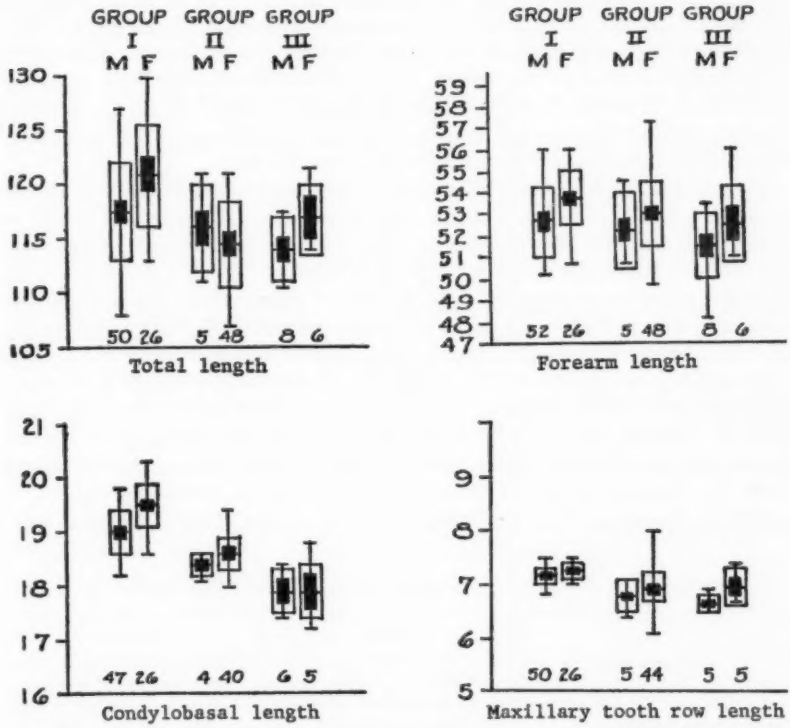


FIG. 2.—A comparison of four different sets of measurements, segregated by sex and by Group. All measurements are in millimeters. Central crossbar indicates the mean; solid box one standard error on each side of mean; hollow box one standard deviation on each side of mean; vertical line extremes of each sample. Numbers indicate numerical size of each sample.

TABLE 2.—*Coefficient of difference values between Groups II and III*

MEASUREMENTS	MALES		FEMALES	
	CD value	Joint non-overlap (%)	*CD* value	Joint non-overlap (%)
Condylobasal length	0.85	80	0.76	78
Maxillary tooth row	0.44	•	—	—
Total body length	0.30	•	0.08	•
Forearm	0.29	•	0.10	•

• Less than 75 per cent joint nonoverlap.

Since the normal depression of the skin in the interscapular region of living bats is not present in dried study skins, the light area may be an artifact resulting from the method of preparation. It is true, however, that the hairs of the interscapular region have only the extreme tips colored broccoli brown as Hibbard described. If in dried skins the hairs surrounding the scapular region are brushed upward, the light area often disappears and there is a lessening in intensity of color of the collar. The ears may be dark or light in either population. Although there are slight differences in color of pelage between the two nominal forms, there seem to be no greater differences between populations than between individuals from the same locality.

The geographic location of Group II is only approximately 250 miles from that of Group I, and approximately 350 miles from Group III. It might at first appear that the Cimarron County group, because of its geographic position, should be considered within the range of *A. bunkeri*. This is not actually true. The 250 miles intervening between the known range of *A. bunkeri* and the collecting sites in Cimarron County are virtually featureless prairie, completely devoid of rocky prominences and canyons. In Cimarron County the land is cleft with rocky canyons, and the same terrain continues virtually unchanged westward to the Rocky Mountains. The apparent lack of records from adjoining parts of Colorado and New Mexico may reasonably be attributed to neglect on the part of collectors. The report by Findley (1954) of an *Antrozous* skull from near Higbee, in Otero County, Colorado bears this out (Fig. 1).

Within the genus there is a clinal variation with slightly increasing mea-

TABLE 3.—*Coefficient of difference values between Groups I and III*

MEASUREMENTS	MALES		FEMALES	
	CD value	Joint non-overlap (%)	*CD* value	Joint non-overlap (%)
Condylobasal length	1.48	93	1.72	96
Maxillary tooth row	1.65	95	0.64	•
Total body length	0.48	•	0.54	•
Forearm	0.41	•	0.40	•

• Less than 75 per cent joint nonoverlap.

surements from west to east. The limits of suitable habitat have isolated the form known as *A. bunkeri* from other members of the genus. Overlapping measurements and general similarity of coloration in *A. bunkeri* and *A. pallidus* do not indicate the validity of the former as a full species. The differences which do exist are of the nature and magnitude usually attributed to subspecies. *A. bunkeri* should therefore be reduced from specific to subspecific rank and designated as *Antrozous pallidus bunkeri* Hibbard, whose range is now known to extend from Barber County, Kansas, south to the western end of the Wichita Mountains in Greer County, Oklahoma.

LITERATURE CITED

Blair, W. F. 1939. Faunal relationships and geographic distribution of mammals in Oklahoma. Amer. Midl. Nat., 22: 85–133.

Burt, W. H. 1945. The Bunker bat in Oklahoma. Jour. Mamm., 26: 309.

———. 1952. A field guide to the mammals. Houghton Mifflin Co., Boston. 200 pp.

Findley, R. B., Jr. 1954. *Notiosorex crawfordi* and *Antrozous pallidus* from Southeastern Colorado. Jour. Mamm., 35: 110.

Glass, B. P. 1949. Report on the mammals of the Black Mesa Region, Oklahoma. Proc. Okla. Acad. Sci., 30: 26–30.

———. 1957. Effectiveness of Japanese mist nets for securing bats in temperate latitudes. SW. Nat., 1: 136–138.

Hibbard, C. W. 1934. *Antrozous bunkeri*, a new bat from Kansas. Jour. Mamm., 15: 227–228.

Krutzsch, P. H. 1955. Additional data on the bacula of North American bats. Jour. Mamm., 36: 96–100.

Maerz, A. and M. R. Paul. 1930. A dictionary of color. McGraw-Hill, New York. 207 pp.

Mayr, E., E. G. Linsley and R. L. Usinger. 1953. Methods and principles of systematic zoology. McGraw-Hill, New York. 328 pp.

Miller, G. S., Jr., and R. Kellogg. 1955. List of North American Recent mammals. U.S. Nat. Mus., Bull. 205, 953 pp.

Orr, R. T. 1954. Natural history of the pallid bat, *Antrozous pallidus* (Le Conte). Proc. Calif. Acad. Sci., Ser. 4, 28: 165–246.

Ridgway, R. 1912. Color standards and color nomenclature. Ridgway, Wash., D.C. 43 pp.

Schwartz, A. 1955. The status of the species of the *brasiliensis* group of the genus *Tadarida*. Jour. Mamm., 36: 106–109.

Twente, J. W., Jr. 1955. Aspects of a population study of cavern-dwelling bats. Jour. Mamm., 36: 379–389.

[Contribution No. 261, Oklahoma State University, Department of Zoology. This Research was supported, in part, by Grant E819, National Institutes of Health.]

Dept. of Zoology, Oklahoma State Univ., Stillwater. Received 11 December 1958.

IDENTITY OF THE LONG-EARED MYOTIS OF THE SOUTHWEST AND MEXICO

By James S. Findley

The long-eared myotis, *Myotis evotis* (H. Allen), has long been regarded as occurring throughout the western United States and southward in Mexico to Jalisco and Veracruz. Recently descriptions of two new subspecies of *Myotis evotis* have appeared. Baker and Stains (Univ. Kans. Publ., Mus. Nat. Hist., 9: 81–84, 10 Dec. 1955) described *Myotis evotis auriculus*, type locality Sierra de Tamaulipas, Tamaulipas, and ascribed to it a geographic range including the coastal foothills and adjacent mountains of northeastern Mexico from central Coahuila south and east to central Veracruz. Hoffmeister and Krutzsch (Nat. Hist. Misc., Chicago Acad. Sci., 151: 1–4, 28 Dec. 1955) described *M. e. apache*, type locality Graham Mountains, Graham Co., Arizona, and, seemingly unaware of the work of Baker and Stains, published but 18 days earlier, ascribed to *M. e. apache* a geographic range which includes southeastern Arizona and Mexico south to Veracruz and Jalisco.

On 25 June 1957, E. D. Fleharty and I captured 27 specimens of *Myotis* in a mist net draped over a small, partially filled water tank in Springtime Canyon, San Mateo Mountains, 38 miles south and 6 miles west of Magdalena, Socorro Co., New Mexico. Of these specimens seven are referrable to *Myotis evotis apache*. This is the first time this form has been recorded in New Mexico, but the record is of special interest since, of the remaining 20 bats taken by us at this station on 25 June, six are typical *Myotis evotis evotis*. The situation indicated the need for a review of these southwestern long-eared *Myotis* which is undertaken here.

I am indebted to D. F. Hoffmeister, E. R. Hall, E. L. Cockrum, D. H. Johnson, W. H. Burt and Richard Van Gelder for their generosity in allowing me to examine specimens in their care.

According to Hoffmeister and Krutzsch, *M. e. apache* differs from *M. e. evotis* in the following respects: light brownish rather than blackish ears; shorter ears; wing and tail membranes lighter brown; hairs on dorsum brown at base rather than black; median process on posterior margin of palate usually broad, long, and rounded rather than short and pointed. All these features are seen in our specimens and serve to distinguish them at a glance from typical *evotis*. In addition, I note that *apache* differs from *evotis* in these respects: more abruptly rising forehead owing to more inflated frontal region; protocone-hypocone area of M^2 which is narrower anteroposteriorly in *apache*; more laterally flared angular process of dentary; relatively longer dentary (more than 82.5% of condylobasilar length in *apache*, less in *evotis*); fewer and more scattered hairs on the free border of the uropatagium (at a magnification of 7× these hairs are seen to form a definite fringe in *M. e. evotis* but do not form a fringe on *M. e. apache*).

According to Baker and Stains, *Myotis evotis auriculus* differs from *M. e.*

evotis in having: shorter ears; color darker and richer; ears paler and contrasting less in color with pelage; skull larger in all measurements taken except that of least interorbital constriction; forehead, when viewed laterally, rising more abruptly because frontal region is more inflated; teeth larger; relatively longer mandible. In examining the type and one topotype of *M. e. auriculus*, I find that they also differ from *M. e. evotis* in all the supplementary features listed above as distinguishing *M. e. apache* from *M. e. evotis*.

Comparison of the Tamaulipan specimens of *M. e. auriculus* with the Arizonan and New Mexican specimens of *M. e. apache* reveals that the two forms resemble one another in all essential features, though the topotypical examples of *auriculus* are somewhat darker in color of pelage. Specimens from other localities in Mexico, for example those from Coahuila, Veracruz, Jalisco and Chihuahua, agree in essential features with both *apache* and *auriculus*, though none is as dark in color of pelage as is *auriculus*. It thus seems certain that the subspecies *apache* and *auriculus*, while made up of animals which are slightly different in color, pertain to the same specific entity. It is further evident, because of the sympatric occurrence of *apache* and *evotis* at Springtime Canyon, that *apache* and *auriculus* are not races of *Myotis evotis*. The question now remains as to the specific identity of the bats to which the names *apache* and *auriculus* have been applied.

Two possibilities suggest themselves. It may be that *apache* and *auriculus* belong to a species not hitherto recognized as distinct, in which case the specific name *Myotis auriculus* Baker and Stains would apply. However, the likelihood that the two subspecies pertain to some well-known species should not be overlooked. No other western species of *Myotis* seems especially close to *apache*. Perhaps the closest species in general appearance is *M. thysanodes*, but it is quite distinct morphologically and, in addition, was taken at Springtime

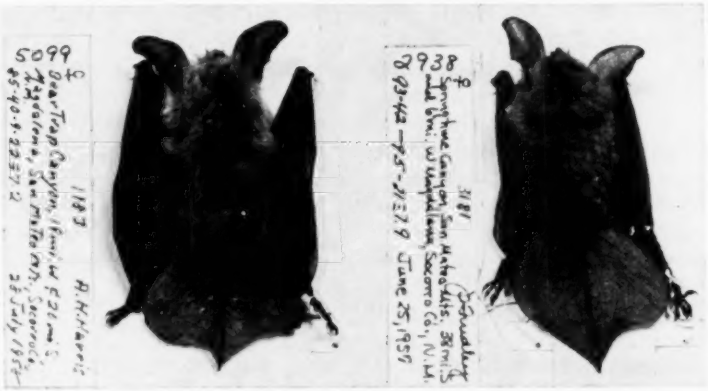


PLATE I

LEFT: *Myotis evotis evotis*. RIGHT: *Myotis keenii apache*. Both animals from the San Mateo Mountains, Socorro Co., New Mexico. Note the difference in pigmentation of the ears.

Canyon along with examples of *apache*. Among eastern species of *Myotis* a close resemblance between *auriculus* and *apache* on the one hand and *Myotis keenii* (Merriam) on the other is at once apparent. *Myotis keenii* is a long-eared bat which has often been mentioned as being close to *M. evotis*. From *M. evotis*, *M. keenii septentrionalis* (Trouessart) differs in its smaller size; shorter ears; sparsely scattered hairs on free border of uropatagium instead of numerous hairs forming a fringe; usually blunt and rounded rather than short and acute palatal spine; relatively smaller hypocone-protocone area of M^2; more abruptly rising forehead and inflated frontal region; less blackish ear and flight membranes; relatively longer dentary. In all these features except in actual size *M. k. septentrionalis* resembles *apache* and *auriculus*. *Myotis keenii septentrionalis* is markedly smaller than either *apache* or *auriculus*. At present no geographically or morphologically intermediate populations are known between either eastern or northwestern populations of *M. keenii* and *apache-auriculus*, so the test of intermediacy cannot be applied to the question of conspecificity. However, the animals referred to by the names *apache*, *auriculus* and *septentrionalis* resemble each other closely, differing only in color and size. The same morphological features serve to separate all three forms from other species of *Myotis*. It seems logical to regard *apache*, *auriculus* and *septentrionalis* as subspecies of the same species, a course followed here. Accordingly, the nomenclature of the bats under consideration would now be as follows:

Myotis keenii keenii (Merriam)
Myotis keenii septentrionalis (Trouessart)
Myotis keenii auriculus Baker and Stains
Myotis keenii apache Hoffmeister and Krutzsch

This arrangement does not convey the relationships of the forms involved as well as it might. The populations represented by these subspecific names are not equally distinct and probably stand in different degrees of relationship to one another. The two southwestern forms are very close and form a distinct unit apart from *M. k. septentrionalis*. I have not examined specimens of *M. k. keenii*. However, a specimen from ½ mile east of Buckhorn, Weston Co., Wyoming, seems to approach the nominate subspecies in darker color of the pelage, ears and flying membranes. The race *M. k. auriculus* is but slightly differentiated from *M. k. apache*. Only the specimens of the former from Tamaulipas and Nuevo Leon seem to me at all distinctive. The specimen from Perote, Veracruz, is preserved in alcohol and it is impossible to evaluate its color. It seems probable that *M. keenii* from Veracruz would be somewhat darker than those from the arid west.

Hoffmeister and Krutzsch note that a specimen which they assign to *M. evotis apache*, from the White Mountains of Arizona, probably from Cooley's Ranch, comes from near a locality (4 miles south of Hannagan Meadow, Greenlee Co., Arizona) where a typical *M. e. evotis* was taken. These authors suggest that the specimen assigned to *apache* may actually be a faded *evotis*. In view of the

findings herein reported it seems likely that this is another example of the sympatric existence in the Southwest of *Myotis evotis* and *M. keenii*.

None of the few continental Mexican specimens formerly referred to *M. evotis* seems referrable to this species. Thus the southern limit of the species (disregarding Baja California and southern California) seems to lie in Arizona and New Mexico (Fig. 1).

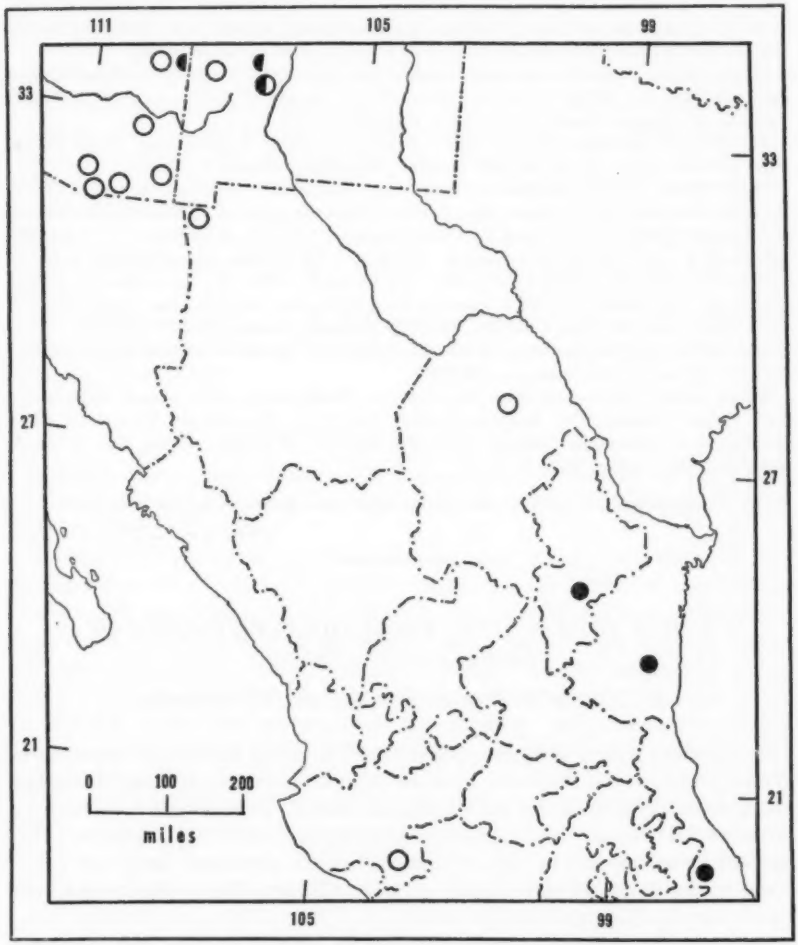


FIG. 1.—Map showing some localities for *Myotis evotis evotis* (black semicircles), *M. keenii auriculus* (solid black circles), and *M. k. apache* (open circles). The half-solid and half-open circle in New Mexico represents the Springtime Canyon station where both *M. evotis* and *M. keenii* were taken. See text for further explanation.

SPECIMENS EXAMINED

In the following list of specimens examined, those from collections other than the University of New Mexico Collection of Vertebrates are identified by the initials KU (University of Kansas Museum of Natural History), IU (University of Illinois Museum of Natural History), AMNH (American Museum of Natural History), USNM (United States National Museum), UMMZ (University of Michigan Museum of Zoology), and AU (University of Arizona Department of Zoology). Localities followed by a literature reference represent specimens which I have not seen. In Arizona and New Mexico localities are arranged from north to south. If two or more occur at the same latitude, the westernmost is listed first. Localities printed in italic type are not plotted on the map (Fig. 1) because of undue crowding.

Myotis keenii septentrionalis.—MICHIGAN: Isle Royale, 4 (UMMZ); Ontonagon Co.: Porcupine Mts., 4 (UMMZ). KANSAS: Marshall Co.: 1½ mi. W and ¼ mi. N Blue Rapids, 3 (KU). WYOMING: Weston Co.: ½ mi. E Buckhorn, 1 (KU).

Myotis keenii auriculus.—NUEVO LEON: Iturbide, 1 (KU). TAMAULIPAS: 10 mi. W and 2 mi. S Piedra, Sierra de Tamaulipas, 2 (KU). VERACRUZ: Perote, 1 (USNM).

Myotis keenii apache.—ARIZONA: Navajo Co.: White Mts. (Hoffmeister and Krutzsch, 1955: 3). Graham Co.: Graham Mts., 3 (IU). Pima Co.: 30 mi. S Tucson (Hoffmeister and Krutzsch, 1955: 3). Cochise Co.: Chiricahua Mts., 3 (AU). Santa Cruz Co.: *7 mi. NW Patagonia,* 1 (AU); 2 mi. W Patagonia, 1 (AU); *1 mi. E Pena Blanca Spring,* 1 (AU). Cochise Co.: Huachuca Mts. (Hoffmeister and Krutzsch, 1955: 3). NEW MEXICO: Catron Co.: 3 mi. NE Aragon, 1 (KU). Socorro Co.: Springtime Canyon, San Mateo Mts., 7. CHIHUAHUA: *east side San Luis Mts., on New Mexican boundary line,* 1 (USNM); 5 mi. N and 2½ mi. W San Francisco, 1 (KU). COAHUILA: 4 mi. W Hacienda la Mariposa, 3 (KU). JALISCO: Los Masos, 1 (AMNH).

Myotis evotis evotis.—ARIZONA: Greenlee Co. (Hoffmeister and Krutzsch, 1955: 2–3). NEW MEXICO: Socorro Co.: Beartrap Canyon, San Mateo Mts., 19 mi. W and 20 mi. S Magdalena, 9; Springtime Canyon, San Mateo Mts., 6. WYOMING: Teton Co.: 2 mi. N Blacktail Butte, Jackson Hole, 1.

Dept. of Biology, Univ. of New Mexico, Albuquerque. Received 3 December 1958.

A NEW ANTILOCAPRID FROM THE PLEISTOCENE OF KNOX COUNTY, TEXAS

BY CLAUDE W. HIBBARD AND WALTER W. DALQUEST

In January 1956, a biology student at Midwestern University reported to Walter Dalquest the discovery of fossil bone in an exposure along the valley of the South Wichita River near Gilliland, Texas. The student later brought pieces of the bone to class. They proved to be the scutes of a glyptodon. This resulted in an intensive search of the Pleistocene exposures along the valley walls of the South Wichita River, in Knox County, Texas, during the past three years by Dalquest and his students.

Hibbard visited the area with Dalquest in 1956, 1957 and 1958, to study the stratigraphy and to collect samples of the volcanic ash occurring in the Pleistocene deposits of the area, as well as to take samples of matrix containing abundant mollusk remains, that occur below the volcanic ash, for washing.

The fossils recovered are from the Seymour formation. They occur below the Pearlette Volcanic ash (Powers, Young and Barnett, 1958, p. 1631) and are correlated with the Cudahy fauna of northwestern Texas (Johnston and Savage, 1955, p. 46); western Oklahoma and southwestern Kansas (Hibbard, 1958, p. 11).

Horn-cores of an antilocaprid that are distinct from previously reported remains are placed on record, owing to the known stratigraphic occurrence of the specimen.

Thanks are extended to Bruce Burnett and O. L. Patterson for permission to remove matrix from their ranches for the recovery of fossils and samples of ash for study. We are grateful to Ada Swineford, State Geological Survey of Kansas, and Howard A. Powers, U.S. Geological Survey, for their identification of the volcanic ash from Knox County, Texas.

We were aided in the study by the loan of the holotype and specimen No. 39061, of *Tetrameryx irvingtonensis* Stirton, by Donald E. Savage, Museum of Paleontology, University of California, and the loan of a cast of the holotype of *Tetrameryx shuleri* Lull by Joseph T. Gregory, Peabody Museum, Yale University.

The illustration was made possible by the financial support accorded the senior author by the National Science Foundation for the study of Pleistocene faunas, project G-5635.

Tetrameryx? knoxensis sp. nov.

Holotype.—No. 33642, Museum of Paleontology, University of Michigan, part of skull and left horn-cores. Collected by Walter W. Dalquest (Field No. 132), 27 January 1956.

Horizon and type locality.—From the sand and gravel of the Seymour formation, below the Pearlette ash horizon; Gilliland local faunule of late Kansan (2nd glacial) age. Taken 3½ miles south by east of Gilliland from an exposure along the north valley wall of the South Wichita River, Knox County, Texas.

Diagnosis.—An antilocaprid with the posterior horn-core longer and larger than the anterior horn-core. A very shallow groove (sulcus) is present along the mid-line of the external surface of the posterior core. Horn-cores greater in diameter than those of *Stockoceros* and *Tetrameryx shuleri* and more elliptical in cross section than those of *T. irvingtonensis.*

Description of holotype.—Tips of both horn-cores are missing but it is evident that the posterior horn-core was longer than the anterior. Whether it terminated rather bluntly and was only slightly longer than the anterior horn-core, or was greatly elongated as the posterior horn-core of *Tetrameryx,* is unknown.

The anterior horn-core is nearly complete. Its length from the supraorbital foramen to the tip is 110.5 mm.; the anteroposterior diameter (Fig. 1) taken at A′–A′ is 38.0 mm.; the transverse width at this point is 26.5 mm. The anteroposterior diameter of the posterior horn-core taken at B′–B′ is 43.7 mm.; the greatest transverse width at this point is 25.0 mm.

The anteroposterior length of the base of the horn-cores is 79.0 mm. The measurement of the cast of *Tetrameryx shuleri* taken at the same place has a base length of 60.0 mm., while that of *T. irvingtonensis* (39061 UCMP) is 71.0 mm.

Discussion.—Tetrameryx? knoxensis is distinct from *S. conklingi* Stock (1930) and *S. onusrosagris* (Roosevelt and Bruden) Skinner (1942) because of its larger size and the unequal length of the horn-cores. There is a slight tendency for the base of the posterior horn-core to curve anteriorly but not to the extent that the curvature is developed in *Tetrameryx irvingtonensis.*

Tetrameryx shuleri and *T. irvingtonensis* both possess a well-developed groove along the posterior horn-core which is better developed than the groove on *T.? knoxensis.* Lull (1921, p. 166) states, concerning the posterior horn-cores of *T. shuleri,* "Externally they bear a groove which passes around on to the anterior surface to become external again as the summit of the horn is reached." Savage (1951, p. 721) remarks, concerning the groove on the posterior tine in *T. irvingtonensis,* that it is like that in *T. shuleri,* but never attains a comparable degree of anterior position.

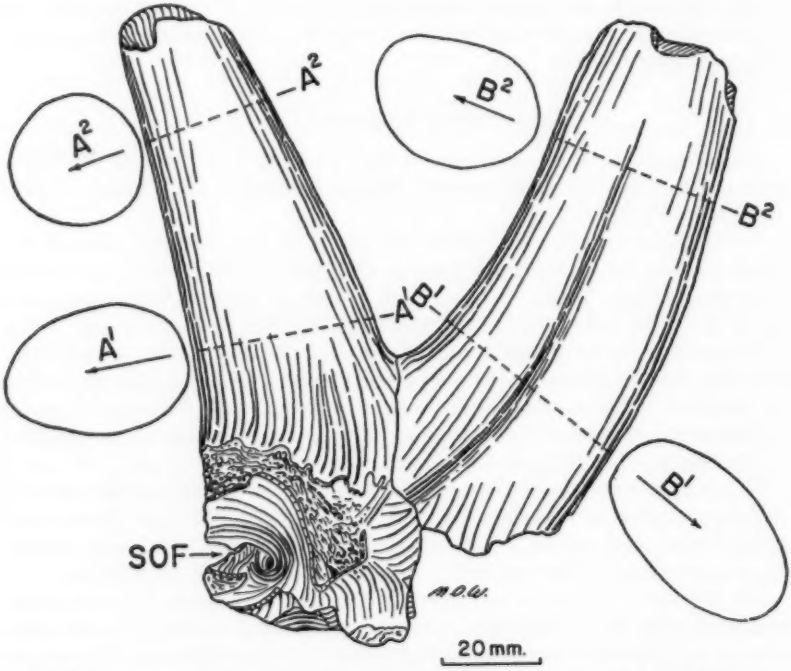


FIG. 1.—*Tetrameryx? knoxensis,* sp. nov. Holotype, UMMP 33642, left horn-cores. Lateral view. Drawing by Michael O. Woodburne.

In *T. shuleri* the horn-cores flare outwardly while in *T. irvingtonensis* the posterior horn-cores curve decidedly toward the mid-line of the skull. Savage (1951, p. 271) states that the anterior tine curves slightly toward the median line of the skull.

The general shape of the base of the horn-cores of *Tetrameryx? knoxensis* appears more like that in *Stockoceros* than in *Tetrameryx*, but owing to the unequal length of the horn-cores the specimen is placed questionably in the genus *Tetrameryx*.

LITERATURE CITED

HIBBARD, CLAUDE W. 1958. Summary of North American Pleistocene mammalian local faunas. Papers Mich. Acad. Sci., Arts and Lett., 43: 3–32.

JOHNSTON, C. STUART AND DONALD E. SAVAGE. 1955. A survey of various late Cenozoic vertebrate faunas of the Panhandle of Texas, Part I. Univ. Calif. Publ. Geol. Sci., 31 (2): 27–50.

LULL, RICHARD SWANN. 1921. Fauna of the Dallas sand pits. Amer. Jour. Sci., 2: 159–176.

POWERS, HOWARD A., EDWARD J. YOUNG AND PAUL R. BARNETT. 1958. Possible extension into Idaho, Nevada, and Utah of the Pearlette ash of Meade County, Kansas. Bull. Geol. Soc. Amer., 69 (12, pt. 2): 1631.

SAVAGE, DONALD E. 1951. Late Cenozoic vertebrates of the San Francisco Bay Region. Univ. Calif. Publ. Geol. Sci., 28 (10): 215–314.

SKINNER, MORRIS F. 1942. The fauna of Papago Springs Cave, Arizona, and a study of *Stockoceros*. Bull. Amer. Mus. Nat. Hist., 80 (6): 143–220.

STOCK, CHESTER. 1930. Quarternary antelope remains from a second cave deposit in the Organ Mountains, New Mexico. Los Angeles Mus. Publ., No. 2: 1–18.

Museum of Paleontology, Univ. of Michigan, Ann Arbor, and Dept. of Biology, Midwestern Univ., Wichita Falls, Texas. Received 4 June 1959.

RESPONSES OF WHITE-TAILED BUCKS TO ADDED ARTIFICIAL LIGHT

BY C. E. FRENCH, L. C. MCEWEN, N. D. MAGRUDER, TERRY RADER, T. A. LONG AND R. W. SWIFT

A 3½-year feeding experiment, to determine the nutrient requirements of the white-tailed deer, *Odocoileus virginianus*, for growth and antler development, was completed in the fall of 1955 (French *et al.*, 1955, 1956; Magruder *et al.*, 1957). During this work definite and predictable seasonal changes in food consumption and live weight were observed. Decreased food consumption and weight losses occurred regularly each fall at the time of the rut and also in winter despite the availability of unlimited amounts of high-quality feed. These changes were followed by a cyclic increase in food intake and weight starting in April and reaching a maximum just prior to the rutting season in September.

Endocrine control of certain seasonal phenomena in wild and domestic animals and birds which is mediated by length of daylight is known as photoperiodism. Pelage changes, migration, and a definite annual breeding season are examples known to be so regulated in many animals of the temperate and more northern zones. Turner (1953) outlined the mechanism of light-controlled seasonal sexual cycles as follows: the length of daylight (either increasing or decreasing hours of light, depending on the species) stimulates the pituitary gland through the optic nerve or tissues of the head; the pituitary produces and releases greater amounts of gonadotropic hormones; and the gonadotropic hormones stimulate the male and female sex glands to a peak of activity at the correct season.

Photoperiodism has been thoroughly studied and demonstrated in some birds and animals, but not in deer (Wislocki, 1943). Marshall (1937) shipped species of European deer from the north temperate to the south temperate zone (England to New Zealand) and vice versa in order to reverse the short and long days of the seasons, and found within three years that the deer had completely reversed their breeding seasons to coincide with their new environments. Bissonnette (1941) found that breeding cycles in goats are controlled by daily periods of light in such a way that short days induce breeding cycles while long days inhibit them. Studies with sheep by Yeates (1949) and Dutt and Bush (1955) indicated that sexual periodicity was regulated by light and temperature. Seasonal changes in hair coats of cattle were shown by Yeates (1955) to be completely dependent on the changing hours of daylight and were not influenced by temperature.

The general plan of this study was to subject a group of six mature male deer to at least 16 hours of light per day throughout the year by means of supplemental artificial light in the morning and evening, and to compare their physiologic performance with that of a similar control group exposed to normal hours of daylight.

Procedures.—The 12 deer selected for this study were males, 3½ years old (except for one of 2½ years). Most of them had varied nutritional histories

TABLE 1.—*Percentage composition of ration*

COMPONENT	POUNDS/100 LBS. RATION
Alfalfa, whole crumbles	38.0
Corn, yellow, ground	34.1
Soybean oilmeal, 46% protein	5.0
Linseed meal, 34% protein	5.0
Cottonseed meal, 41% protein	5.0
Oats, ground	5.0
Salt, trace mineral	1.0
Di-sodium phosphate	1.9
Molasses, "Sweet Mix"	5.0
Vitamin A & D oil*	(51 gm.)

*Contained 3,000 U.S.P. Units of A and 300 I.C. Units of D_3 per gram.

while participating in the previous nutrition studies (French *et al.*, 1955, 1956; Magruder *et al.*, 1957) but only the large and healthy deer were selected. They were then divided into two groups of six deer each so that each group had the same average weight and nearly identical nutritional backgrounds.

They were housed in individual pens (12 × 28 feet) that were located in a secluded area along the western edge of a stand of white pines on a gentle downhill slope that afforded drainage. A 10-foot, light-proof partition was erected near the center of the rows of pens which, with the large pine trees overhead, effectively separated the lighted and unlighted areas during the experimental period from 1 October 1955 to 1 April 1957. Two outdoor-type 75-watt flood lamps were installed about 8 feet above the ground in each of six pens on one side of the light barrier, so as to give complete light coverage in each pen. An automatic time switch was installed and adjusted to turn the lights on from 4 AM to 7 AM and from 5 PM to 8 PM so that the artificial light plus normal daylight amounted to 16 hours daily from 1 October to 1 April. The control pens received only normal daylight which amounted to 10 to 12 hours daily through the winter and spring months. The deer were fed and watered once daily as in the previous study, with all deer receiving the nutritionally complete ration (Table 1). The ration was weighed for each deer daily and the amount increased or decreased according to the previous day's consumption. The deer were weighed at approximately 2-week intervals by herding them along the narrow runway from the pens to the enclosed Toledo balance. However, during the rutting season when the deer reached 4½ years of age, this procedure became increasingly more dangerous and was discontinued. Additional records were maintained on the dates of hair coat change, initiation and maturity of antler growth, and onset and duration of the rut. The eventual antler development attained was also determined by weighing and measuring the shed antlers.

TABLE 2.—*Seasonal changes and dates observed*

	NORMAL DAYLIGHT GROUP	EXTRA LIGHT GROUP
1955 rut	20 October (normal)	6 October (2 weeks early)
Spring change in pelage	April–June (normal)	March–May (3 weeks early)
Antler growth	Budding first observed in March 1956	Budding first observed in February 1956
Average antler length, 1 June	22 inch combined beam length	26 inch combined beam length
Velvet rubbed off antlers	2 Sept. (29 Aug.–7 Sept.)	21 Aug. (5 Aug.–5 Sept.)
Fall change in pelage	September (normal)	August (3 weeks early)
1956 rut	Late October (normal)	Mid October (2 weeks early)
Antler growth	Budding first observed in March 1957	Budding first observed in February 1957

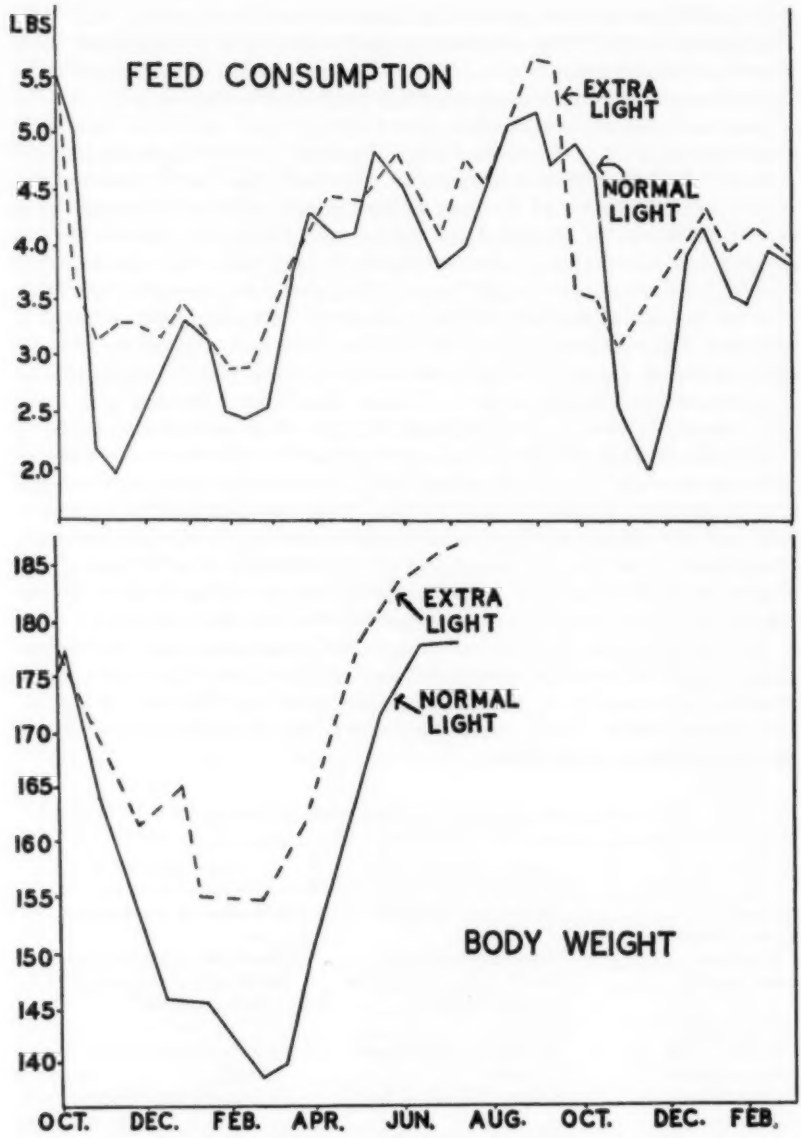


FIG. 1.—Average bimonthly feed consumption and body weight.

Results and discussion.—Seasonal food consumption and body weight changes for the deer subjected to 16 hours of light daily and those exposed to normal daylight are shown in Fig. 1. The six deer in the normal-daylight group exhibited the usual cycle of abrupt decrease in food consumption and weight in October at the onset of the rutting season, slight gains in early winter months, a further decrease in the late winter months, and then rapid recovery and increase in food consumption and weight during the spring and summer.

The six deer receiving 16 hours of light daily responded in the same general way as the control group, but with marked differences in degree and time. The onset of rutting season in this group was advanced approximately 2 weeks as indicated by the earlier drop in food consumption and the data summarized in Table 2. The decrease in food consumption during the rutting season was much less pronounced, and the usual late-winter decrease was almost completely absent, resulting in less winter weight loss. By late winter the control group had lost nearly 20 pounds more per deer on the average than the extra-light group. Most of this difference was eliminated by late summer, so that the final weights in August differed by only 7 pounds. However, a difference of 20 pounds might well be a vital factor in the survival of pregnant females in late winter. The average bimonthly body weight gains and feed consumption (Fig. 1) varied almost directly with the average monthly temperatures (Fig. 2). This is as would be expected since the warmest days occurred during the period of greatest daylight and the coldest days during the period of least daylight.

Spring and fall changes in pelage (hair coat) were advanced about three weeks in the deer subjected to the 16-hour daily light period. Initiation of antler growth and date of maturity, as evidenced by rubbing off the velvet, were also advanced by an average of two to three weeks (Table 1). The deer

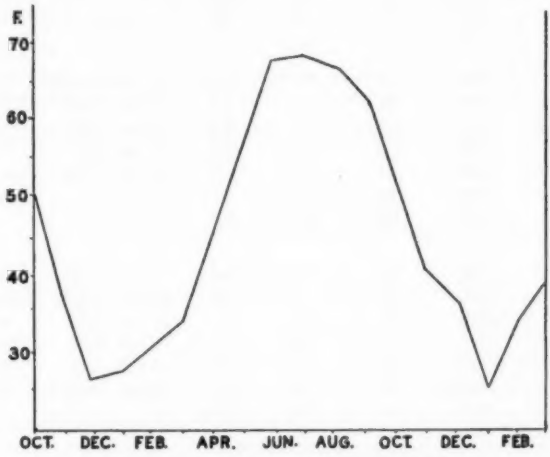


FIG. 2.—Average monthly temperature.

were continued on experiment through the following winter in order to collect the shed antlers for accurate measurement. Despite the usual wide variability, the group receiving extra light showed a tendency to shed their antlers about two weeks earlier than the normal daylight group (Table 3). The mean antler shedding date was 15 January for the extra daylight group, and 27 January for the control group, with standard errors of the mean being 8.8 and 3.5 days, respectively, for the two groups.

The final size of antlers attained, however, was nearly identical in the two groups, as shown in Table 3. All of the deer developed large branched antlers with an average length of the main beam of 20 inches, an average number of 10 to 11 points, and an average diameter of 1.2 inches measured one inch above the antler base.

Since deer apparently respond sexually to decreasing day length, and day length is already decreasing during July, August and September, the response of the animals of the light group to the decreasing days may have been too far advanced to be completely offset by additional light from 1 October.

SUMMARY

These data suggest that light may influence certain seasonal phenomena in white-tailed deer as evidenced by the extra light ameliorating the severe winter decrease in food consumption and weight, and effecting an advance in the time of pelage change, in the initiation, maturing and shedding of the antlers, and in the time of onset of the rutting season. However, extended light exposure did not influence the final size of antlers developed, and it had little effect on the final maximum weight the deer attained just prior to the rutting season.

TABLE 3.—*Antler development attained—October 1955 to October 1956*

GROUP	DEER NO.	AVERAGE WEIGHT OF BOTH ANTLERS, GM.	AVERAGE LENGTH MAIN BEAM, IN.	TOTAL POINTS AND TINES	DIAMETER INCH ABOVE BASE, IN.	DATE ANTLERS SHED	
						Right	Left
Normal Daylight	105	915	17	10	1.2	11 March 1957	13 March 1957
	109	724	21	6	1.1	24 Jan. 1957	25 Jan. 1957
	117	1,593	22	19	1.5	29 Jan. 1957	29 Jan. 1957
	120	856	19	10	1.1	17 Jan. 1957	17 Jan. 1957
	130	799	21	13	1.2	21 Dec. 1956	21 Dec. 1956
	143	887	18	9	1.1	Not shed*	Not shed*
	Avg.	962	20	11	1.2		
Extra Light	106	1,418	23	10	1.4	31 Dec. 1956	30 Dec. 1956
	111	912	21	8	1.2	21 Dec. 1956	21 Dec. 1956
	115	1,095	21	14	1.2	21 Jan. 1957	18 Jan. 1957
	122	691	18	8	1.1	15 Jan. 1957	16 Jan. 1957
	132	(330)†	(16)	(4)	1.0	3 Feb. 1957	3 Feb. 1957
	139	746	17	9	1.2	22 Jan. 1957‡	2 Feb. 1957
	Avg.	972	20	10	1.2		

* Deer killed 8 April 1957 with antlers still attached (age 4 yrs.).
† Injured right antler, developed as stub only.
‡ Antler knocked off in fighting.

ACKNOWLEDGMENTS

The authors express their appreciation to the following individuals who contributed to this investigation: W. M. Sharp, P. F. English, R. M. Latham, S. A. Liscinsky and other wildlife research personnel, for their advice and assistance; and J. F. Hokanson and A. J. Luedke for their aid with veterinary medical problems.

LITERATURE CITED

BISSONNETTE, T. H. 1941. Experimental modification of breeding cycles in goats. Physiol. Zool., 14: 379.

DUTT, R. H. AND L. F. BUSH. 1955. The effect of low environmental temperature on initiation of the breeding season and fertility in sheep. Jour. Animal Sci., 14: 885.

FRENCH, C. E., L. C. MCEWEN, N. D. MAGRUDER, R. H. INGRAM AND R. W. SWIFT. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Pa. Agr. Exp. Sta., Bull. 600 and 600-P, 50 pp.

FRENCH, C. E., L. C. MCEWEN, N. D. MAGRUDER, R. H. INGRAM AND R. W. SWIFT. 1956. Nutrient requirements for growth and antler development in the white-tailed deer. Jour. Wildl. Mgt., 20: 221.

MAGRUDER, N. D., C. E. FRENCH, L. C. MCEWEN AND R. W. SWIFT. 1957. Nutritional requirements of white-tailed deer for growth and antler development. II. Experimental results of the third year. Pa. Agr. Exp. Sta., Bull. 628, 15 pp.

MARSHALL, F. H. A. 1937. On the change over in oestrus cycle in animals after transference across the equator and further observations on the incidence of the breeding season and the factors controlling periodicity. Proc. Roy. Soc. London, Ser. B, 122 (829): 413.

TURNER, C. D. 1953. General endocrinology. W. B. Saunders Co., Philadelphia.

WISLOCKI, G. B. 1943. Seasonal changes in the male reproductive tract of the Virginia deer with a discussion of the factors controlling the antler-gonad periodicity. Essays in Biology, Univ. Calif. Press.

YEATES, N. T. M. 1949. The breeding season of the sheep with particular reference to its modification by artificial means using light. Jour. Agr. Sci., 39: 1.

———. 1955. Photoperiodicity in cattle. I. Seasonal changes in coat character and their importance in heat regulation. Austr. Jour. Agr. Res., 6: 891.

[Authorized for publication on 6 December 1957 as paper No. 2219 in the Journal Series of the Pennsylvania Agricultural Experiment Station; Department of Animal Nutrition paper No. 244; and Pennsylvania Cooperative Wildlife Research Unit paper No. 91.]

Dept. of Animal Nutrition, Pennsylvania State Univ., University Park. Received 1 August 1958.

THE SOUTHERN FORM OF THE PILOT WHALE

BY J. L. DAVIES

Until 1939, the pilot whale of the southern hemisphere was generally considered to be referable to the North Atlantic species, *Globicephala melaena* Traill, 1809, and no osteological or external characteristics which would warrant taxonomic separation had been noticed. However, Rayner (1939) suggested

a new specific name, *G. leucosagmaphora,* for the southern animal on grounds of distinctive pigmentation and geographical distribution. The new species was distinguished "by the possession in the adult of a saddle shaped area of whitish pigment on the dorsal surface posterior to the dorsal fin and a streak of similar pigment about ten to twelve inches long and one to two inches broad situated posteriorly to each eye and running posterodorsally." Color is otherwise as in *G. melaena* and no distinguishing osteological characters could be found.

It is fair to say that the erection of this new species has been generally ignored by writers in the southern hemisphere (for example, Scott, 1942; Barnard, 1954) who have continued to refer to the southern animal as the North Atlantic species, but *leucosagmaphora,* has been treated as a valid species by authors elsewhere (for example, Fraser, 1950; Sergeant and Fisher, 1957). The stranding of a school of about 200 *Globicephala* in southeastern Tasmania in December 1955 gave me an opportunity of examining live and freshly dead specimens and later of collecting a number of skulls. Although it has not been possible to compare the skulls directly with specimens of *G. melaena,* a comparison of measurements and photographs has failed to indicate any notable difference between the northern and southern forms. Indeed, no one has yet suggested such a difference. Rayner did not do so in his specific diagnosis and an examination of the photographs of skulls of *melaena* and *leucosagmaphora* provided by Fraser (1950) will show how indistinguishable are the two forms, at least by gross inspection. Fraser (personal communication) examined a large number of *Globicephala* skulls from the Falkland Islands and could find no difference and Barnard (1954) says that skulls from the Cape of Good Hope and Kerguelen in the South African Museum both resemble *G. melaena.* It is possible that a detailed biometric analysis of a sufficient series will eventually indicate some slight but significant difference, but it seems unlikely that it will prove of more than subspecific importance.

No osteological distinction having been suggested and there being no observable difference in size, external proportions and general coloration, the status of *leucosagmaphora* depends upon the presence of the whitish skin markings alluded to by Rayner (Fig. 1). That the whitish saddle mark behind

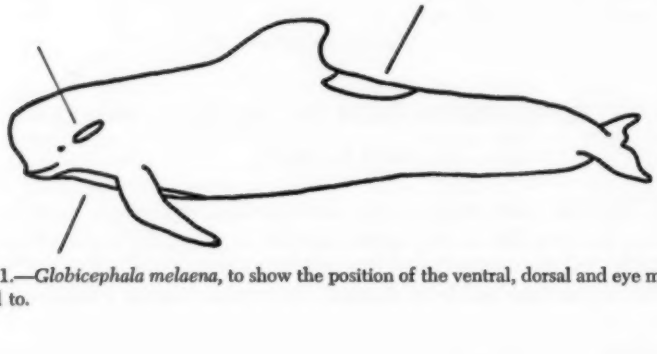


FIG. 1.—*Globicephala melaena,* to show the position of the ventral, dorsal and eye markings referred to.

the dorsal fin and the whitish marks behind the eyes occur in some specimens or even in whole schools is beyond question. Rayner refers to the records of the "Discovery" expedition and Oliver (1924) illustrates a stranded school of animals exhibiting these markings. But what is equally beyond question is that in a large proportion of specimens these distinguishing marks are lacking. Many of the whales stranded in Tasmania in 1955 were examined through binoculars and no such marks were noticed. Further, two accessible adults, still alive, were examined at close quarters and appeared indistinguishable from typical examples of *G. melaena*. There is thus no possibility of accounting for the absence of the marks by postulating that they disappear quickly after death. It is impossible to assess the frequency of occurrence of the non-distinguishable animals but, judging by the number of authors who do not remark upon the presence of such distinctive markings, it seems probable that they are by no means unusual. For example, Cabrera and Yepes (1940) do not mention the markings in describing the South American animal, which they refer to *melaena*. Ellerman, Morrison-Scott and Hayman (1953) listed the South African animal as *Globicephala edwardi* A. Smith, 1834, but Smith's description of *Phocoena edwardii* (quoted in Fraser, 1950) makes no mention of the saddle and eye markings and again there is nothing to distinguish it from *G. melaena*.

Scott (1942) described a school of pilot whales which stranded in Tasmania in 1935 and gave a detailed account of the coloration of two adults. One had a "dark elephant" colored patch behind the dorsal fin but, in the other, this was absent. He mentioned that "in perhaps the majority of cases there was present near the shoulder a region of dark elephant with boundaries moderately sharply marked off from the prevailing body colour." This may be the same marking described by Rayner as occurring behind the eye, but it seems to be of somewhat different shape and to occur further caudad (compare the photograph in Oliver [1924] with Scott's Plate X). According to Scott, the light pattern behind the dorsal fin was less constantly present than the scapular marking and since the latter occurred in "perhaps the majority" of the school, it may reasonably be inferred that the dorsal marking was present in less than half. The dorsal patch appears to be visible on at least two animals pictured in Plate I, Fig. 4, accompanying Scott's account.

In November 1957, a school of about 300 pilot whales was stranded in south-eastern Australia at Port Welshpool in Victoria (Plate I). Photographs published in the Melbourne "Age" on 25 November show a white saddle marking in the case of all five specimens where the dorsal area is visible, but unfortunately I have not been able to ascertain the proportion of the entire school which showed this marking. There is no indication of a white marking behind the eye. On 24 November 1957, E. R. Guiler examined a 10-ft. male *Globicephala* which appeared on the beach at Howrah, Tasmania and reported (personal communication) that it had no white markings other than the usual ventral pattern of *G. melaena*.

The possibility of distinguishing positively by color between *G. melaena* and *G. leucosagmaphora* is further diminished by the fact that W. E. Schevill has pointed out that a percentage of adult *melaena* examined by him in Newfoundland had a dorsal saddle apparently closely resembling that of the southern form (Sergeant and Fisher, 1957). To date, the whitish markings behind the eye have not been described in the North Atlantic animal.

It can be concluded from the foregoing that some southern animals have distinctive eye and dorsal markings, that a few northern and some southern specimens have the dorsal marking only, and that most northern and some southern animals have neither distinctive mark. Further, the markings may vary in color from whitish to dark gray. Another way of putting this is by saying that a taxonomist confronted with a pilot whale with eye and dorsal markings would be reasonably safe in assigning it to the southern form; a whale with dorsal markings only would not so certainly come from the south but could fairly be assumed to do so; whereas a whale on which there was neither marking would be quite unplaceable.

The evidence available at present suggests, therefore, that *G. melaena* and *G. leucosagmaphora* represent one polymorphic species existing in two discrete population groups within which the proportion of color varieties differs markedly. The white ventral marking of *melaena* and *leucosagmaphora* also varies very much in extent, although no one has pointed to any geographical significance in this variation. It seems that such color markings are extremely unreliable characters from a taxonomic point of view and have caused confusion in other odontocete genera (see, for instance, Bierman and Slijper, 1947, on the southern "species" of *Lagenorhynchus*). There is an interesting parallelism in marking between *Globicephala* and the killer whale, *Orcinus orca*, which has a similar eye marking and a similar dorsal saddle which is variable in form and sometimes may be absent.

The second of Rayner's reasons for separating *leucosagmaphora* was its geo-

PLATE I

Part of a school of pilot whales stranded at Port Welshpool, Victoria, in November 1957. Reproduced by permission of the Melbourne "Age."

graphical distribution and this remains to be explained, as its range appears to be separated from that of typical *melaena* by that of the clearly defined tropical species, *G. macrorhyncha* Gray, 1846, which Fraser (1950) showed to be distributed from the Caribbean through the Indian Ocean to the East Indies. The fact that the northern and southern population groups are so separated (Fig. 2) has certainly created a predisposition toward the acceptance of *leucosagmaphora* as a valid and distinct species. Such an antitropical distribution has its parallel elsewhere and the explanation undoubtedly is that the cooling of ocean temperatures in the Pleistocene glacial ages considerably restricted the range of the tropical species of *Globicephala* and allowed communication between the North Atlantic and Southern Ocean population groups. Hubbs (1952), in discussing antitropical marine distributions, followed Berg (1933) and ascribed most such discontinuous occurrences to a cooling and

FIG. 2.—The apparent distribution of *Globicephala melaena*.

subsequent rewarming of tropical waters during the Pleistocene. The last contact between the animals of the two groups may have been little more than 10,000 years ago and it does not necessarily follow that they have yet acquired distinguishing characteristics. Even if infallible distinguishing characters are eventually discovered, it seems most unlikely at this stage that they will prove to be nearly so clearly defined and important as those which separate *G. melaena* from *G. macrorhyncha*, and will not warrant elevation of the southern form to specific rank. If nomenclatorial distinction should be thought necessary or convenient now, it seems preferable to regard the two population groups as subspecies, especially as subsequent more detailed investigation is more likely to confirm or decrease such a taxonomic status than to increase it. In any event, the name *leucosagmaphora* Rayner, 1939, is clearly antedated by that of *edwardi* A. Smith, 1834 (Ellerman, Morrison-Scott and Hayman, 1953). The two forms would then be the North Atlantic pilot whale, *G. m. melaena*, and the southern pilot whale, *G. m. edwardi*.

I would like to acknowledge the help and encouragement given me by F. C. Fraser of the British Museum (Natural History), London, in the preparation of this note and also to thank W. E. Schevill of Woods Hole, Massachusetts, and E. O. G. Scott of Launceston, Tasmania, for reading and commenting on the manuscript.

LITERATURE CITED

Barnard, K. H. 1954. A guide book to South African whales and dolphins. Cape Town. 33 pp.

Berg, L. S. 1933. Die bipolare Verbreitung der Organismen und die Eiszeit. Zoogeographica, 1: 444–484.

Bierman, W. H. and F. J. Slijper. 1947. Remarks upon the species of the genus *Lagenorhynchus*. I. Proc. K. ned. Akad. Wet. Amsterdam, 50: 1353–1364.

Cabrera, A. and J. Yepes. 1940. Mamiferos sud-Americanos. Historia Natural Ediar. Compañia Argentina de Editores, Buenos Aires. 370 pp.

Ellerman, J. R., T. C. S. Morrison-Scott and R. W. Hayman. 1953. Southern African mammals. London. 363 pp.

Fraser, F. C. 1950. Two skulls of *Globicephala macrorhyncha* (Gray) from Dakar. Copenhagen. Altantide Report, No. 1: 49–60.

Hubbs, C. L. 1952. Antitropical distribution of fishes and other organisms. Proc. 7th Pac. Sci. Cong., 3: 324–329.

Oliver, W. R. B. 1924. Stranded blackfish at Marsden Point, N. Z. Jour. Sci. Tech., 7: 188–189.

Rayner, G. W. 1939. *Globicephala leucosagmaphora*, a new species of the genus *Globicephala*. Ann. Mag. nat. Hist., 11 (4): 543–544.

Sergeant, D. E. and H. D. Fisher. 1957. The smaller Cetacea of eastern Canadian waters. Jour. Fish. Res. Bd. Canada, 14: 83–115.

Scott, E. O. G. 1942. Records of Tasmanian Cetacea. II. A large school of the pilot whale, *Globicephalus melas* (Traill, 1809), stranded at Stanley, northwestern Tasmania in October 1935. Rec. Queen Vict. Mus., Tasm., 1(2): 5–34.

Dept. of Geography, Univ. of Tasmania, Hobart. *Received 7 July 1958.*

REPRODUCTION IN THE POCKET GOPHER IN NORTH-CENTRAL FLORIDA

By Elizabeth S. Wing

The southeastern pocket gopher, *Geomys pinetis* Rafinesque, is common in parts of Alabama, Georgia, and Florida, yet relatively little is known of its reproductive habits. The objective of this study was to gain as much detailed information as possible on various aspects of reproduction in this species. Field work was done from July 1956 through June 1957, within a 15-mile radius of Gainesville, Alachua County, in north-central Florida. The taxonomic status of the pocket gopher in this region is not well understood, although the population has been considered by Sherman (1936) to exhibit evidence of intergradation between the subspecies *floridanus* and *austrinus*.

MATERIALS AND METHODS

A total of 325 pocket gophers was collected throughout the year. Monthly samples averaged 27.5 specimens and ranged from 12 to 34. The animals were trapped in their burrow systems with Victor gopher traps used in pairs. The weight, total length, tail length, and hind foot length of each specimen were recorded. Females were examined for the condition of the teats, vulva, and pubic symphysis (whether intact or resorbed). The relative development of the reproductive tract was noted, and measurements of the length and breadth of the ovaries and uteri were taken. In males the appearance of the testes was noted, and the weight and measurements of a single testis were taken. The seminal vesicles were also measured and their degree of development recorded. The cauda epididymis was measured and examined for the relative size of its tubules. A smear made of the severed epididymal tubules was examined microscopically for the presence or absence of sperm.

Skulls of all specimens were saved for use in establishing age classes, and a series of 70 flat skins was also prepared, as pelage characteristics provided an additional age criterion.

SEX AND AGE COMPOSITION

For consideration of sex and age ratios, three age classes were recognized. Animals which had attained sexual maturity were classed as adults, whereas those which had not previously bred nor were in breeding condition when trapped were considered to be immature. The immature animals which were larger than 200 mm. in total length and weighed more than 100 gms. were denoted as subadult, while those weighing less than 100 gms. and measuring less than 200 mm. were classed as juveniles. All individuals in the latter category were either still in the soft, gray juvenile pelage or in the initial stages of the post-juvenile molt.

Criteria useful in determining the age and reproductive status of females were the size and appearance of the teats, ovaries, and uteri, and the condition

of the pubic symphysis and vulva. The pubic symphysis, which resorbs at puberty (Hisaw, 1923, 1925), was intact in all specimens classed as immature on the basis of other criteria, and resorbed in all adults. The vulva was sealed in all immature females examined and in adults in anestrous and post-partum condition. During estrus, pregnancy, or just after parturition, the vulva was either open or lightly sealed with mucus. Copulation plugs were found in the vaginae of two animals, one caught 9 March, and the other 5 April. The teats of immature females ranged from 0.5 to 1 mm. in length and were well hidden in the fur. The mammary tissue in these animals was very small in extent and inconspicuously vascularized. Adults in anestrum differed from prepubertal individuals only by having slightly larger teats (over 1 mm.) and a greater amount of mammary tissue. Late pregnant and lactating females had enlarged teats surrounded by bare skin and well-developed mammary tissue with prominent vascularization. During lactation the epithelium of the teats became thickly cornified. All except two specimens examined had three pairs of teats; these two each had four pairs.

The uteri of immature females averaged 19.8 mm. (15–27) in length and were no more than 1.5 mm. in width. In adults, uterine length ranged from 16 to 42 mm., with a mean of 28.8, and uterine width exceeded 1.5 mm. The ovaries of immature animals were white and sliver-like in shape and averaged 3.3 mm. (1–4) in length. Those of adults were more spherical and larger, averaging 4.4 mm. (2–6). Graafian follicles in estrous females appeared as small blisters on the surface of the ovary, whereas corpora lutea of pregnancy were visible as small reddish or yellowish swellings. Subadult and anestrous adult females could be distinguished by the appearance of the uteri, the latter being slender and imperceptibly vascularized in the nonbred and flaccid and indistinctly vascularized in the parous individuals. At estrus the uteri became noticeably swollen, turgid, and conspicuously vascularized. During pregnancy the entire tract was enlarged, extremely vascular, and flaccid except in the region of a uterine swelling. Shortly following parturition the uterus was shrunken, with the uterine muscles thrown into narrow folds. Placental scars apparently persist for some time. Seven females had two sets of placental scars in the uteri, and an old placental scar was visible in the uterus of one of the pregnant animals examined. Scheffer (1938) stated that placental scars persist at least two weeks following parturition. The present data indicate that they may persist for perhaps three months in some females of *G. pinetis*.

In the male the testis, cauda epididymis, and seminal vesicles of the subadult and sexually active and inactive adults varied considerably in size and appearance (Table 1). The subadult testis was uniformly pink in color. In contrast, the testes of sexually inactive adults were cream-colored and possessed a markedly thickened tunica albuginea. The testes of breeding males were well vascularized by large wavy blood vessels on the surface. The cauda epididymis of subadults was small and pink, and the tubules were not discernible without magnification. The epididymis of the adult in male anestrum was similar to

TABLE 1.—*Measurements (in gms. or mm.) of testis, cauda epididymis, and seminal vesicles of immature and mature male Geomys pinetis*

MEASUREMENT	IMMATURE (48)		MATURE (86)			
			Nonbreeding (10)		Breeding (76)	
	Mean	Range	Mean	Range	Mean	Range
Testis weight	0.10	0.05–0.25	0.28	0.22–0.37	0.36	0.20–0.68
Testis length	6.6	4–11	9.7	9–11	11.3	8–14
Cauda epididymis width	2.2	0.5–5	3.3	3–4	4.1	3–6
Seminal vesicle length	3.5	1–7	6.6	3–9	8.5	5–14

that of the subadult in appearance but could generally be distinguished by its larger size. The cauda epididymal tubules in the breeding adult were conspicuous to the unaided eye due to the storage of fat (Hill, 1937) and engorgement with sperm. The seminal vesicles of the subadult were flaccid and pinkish. The seminal vesicles of the actively reproducing adult were turgid and translucent, whereas those of the inactive adults were opaque. In males approaching breeding condition the development of the seminal vesicles seemed to lag behind that of the testes, and the former appeared to remain turgid and enlarged after the gonads had begun to diminish in size.

Sex ratios.—The total of 325 specimens collected consisted of 134 males and 191 females, an over-all sex ratio of 41 per cent males to 59 per cent females. The difference in the proportion of sexes is statistically significant (Chi-square = 4.998). A similar discrepancy in the sex ratio is apparent when the data are considered from the standpoint of the three age classes previously defined (Table 2). This same trend is also reflected in a seasonal breakdown of the numbers of adult, subadult, and juvenile males and females taken. The numbers of females exceed the numbers of males in all but three cases: the December through February sample of adults, the June through August sample of subadults, and the March through May sample of juveniles.

A similar discrepancy in the sex ratio of *Geomys breviceps* [= *bursarius*] was reported by Wood (1949). The primary sex ratio (embryos and nestlings) obtained in his study was 44.8 per cent males to 55.2 per cent females. The

TABLE 2.—*Total and seasonal sex ratios of juveniles, subadults and adults*

SEASON	JUVENILE			SUBADULT			ADULT		
	Number ♂	Number ♀	% ♂	Number ♂	Number ♀	% ♂	Number ♂	Number ♀	% ♂
December–February	0	2	0	5	11	31	40	34	54
March–May	2	1	67	2	8	20	24	44	35
June–August	3	5	38	8	3	73	16	24	40
September–November	5	7	39	5	11	33	24	41	37
Total	10	15	40	20	33	38	104	143	42

secondary sex ratio (subadults and adults) was even more divergent, consisting of 40.4 per cent males to 59.6 per cent females. This secondary sex ratio is very close to that found for *G. pinetis*. Since none of the embryos obtained in this study could be sexed, comparative data for the primary sex ratio are not available.

The reason for the observed higher proportion of females is not known. It is conceivable that the population did actually consist of more females than males as a result of a differential uterine or post-natal mortality. On the other hand, the unbalanced sex ratio may be the result of a difference in activity of the sexes, the females perhaps being more active than the males. If one reflection of greater activity is increased burrowing activity, then the method of collecting employed would have selected for the more active sex, since traps were usually set in the tunnels below fresh mounds.

Age ratio.—Immatures made up approximately 24 per cent of the total number of specimens examined (Table 3). The incidence of juveniles was low in the first half of the year and increased in the latter half. The percentage of subadults was lowest, and the percentage of adults highest, from March through May.

TABLE 3.—*Total and seasonal age ratios*

SEASON	JUVENILE		SUBADULT		ADULT	
	Number	%	Number	%	Number	%
December–February	2	2	16	17	74	80
March–May	3	4	10	12	68	84
June–August	8	14	11	19	40	68
September–November	12	13	16	17	65	70
Over-all Total and %	25	8	53	16	247	76

BREEDING SEASON

Males in breeding condition, as indicated by enlarged testes and accessories and the presence of sperm in the epididymis, were found in each month of the study. The highest percentages (65 to 95) of sexually active males occurred from January through June (Fig. 1). All adult males were fertile from February through September, but in the interval from October through January only from 63 to 75 per cent of the adults collected in each month were in breeding condition. The remaining adults examined during the latter period showed involution of the genital system, and sperm were either very sparse or entirely absent in smears. These data suggest that a period of intensified reproductive activity in males occurs from January through August, although some sexually active males occur generally throughout the year.

The reproductive status of all females collected is presented in Fig. 2. On the basis of these data and the work of Barrington (1940), which also includes data provided by H. B. Sherman, pregnant *G. pinetis* have been collected in

every month of the year except September and November. The size of the embryos carried by females taken 7 October (by Barrington) and 15 December indicates the occurrence of conception in September and November as well. Thus, breeding in the southeastern pocket gopher seems to be continuous throughout the year. However, monthly frequencies of pregnant and lactating individuals and specimens with fresh placental scars indicate spring and late summer peaks in breeding activity.

The length of the breeding season has been reported for several species of *Thomomys* and *Geomys* by Bond (1946), English (1931), Miller (1946), Scheffer (1938), Wight (1930), and Wood (1949). *Geomys pinetis* appears to have the most prolonged breeding season of any of these, except for *T. bottae* in the southern parts of its range (Miller, 1946). Peaks in reproductive activity similar to those indicated by the present data were reported for *G. b. brazensis* (Wood, 1949) and *T. bottae* (Miller, 1946).

Age at weaning and sexual maturity.—Miller (1946) found that young *Thomomys bottae* were weaned at 35 to 37 days and maturity was reached in about three months. According to Wood (1949), *Geomys breviceps* also ma-

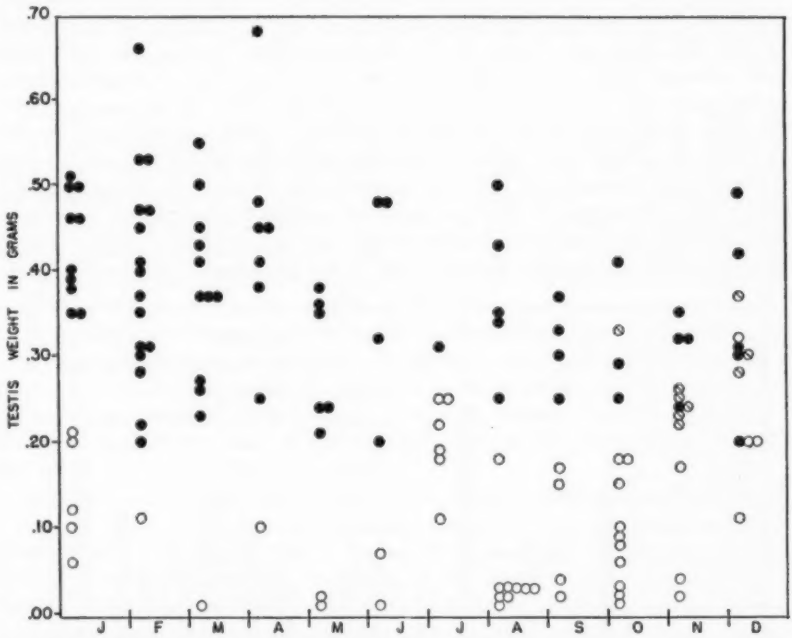


FIG. 1.—Scatter diagram showing the weights of testes during each month of the study. Solid black circles indicate presence of sperm in the cauda epididymis; empty circles indicate absence of sperm; circles with a diagonal line denote the testis of a regressed adult lacking sperm in the epididymis.

tures in about three months. In *Geomys pinetis,* however, both sexes may take nearly six months to attain maturity. Males born in winter or spring probably do not become sexually mature until fall, while those born in summer or fall do not reach maturity until winter. Evidence for this is that no influx of young adults during the second peak of breeding was observed, which presumably would have been the case if young of the first breeding peak were becoming mature in three months; and the fact that there appeared to be an increased proportion of young breeding in the first part of the year. The increased percentage of subadult females and the decreased percentage of adults collected in the summer indicate that the females born in the early spring do not breed until after late summer or early fall and perhaps not until the following year. In *G. breviceps* (Wood, 1949) and *T. bottae* (Miller, 1946) the weight of the pregnant females in the summer was lower than in the spring, indicating that summer-breeding animals included individuals born in the spring. This trend was not evident in the breeding females of *G. pinetis* examined during the two peaks of breeding activity.

Relation between the sexes.—Little is known about the interrelationships of sex and age groups in the pocket gopher, although the assumption is generally made that the adult animals are solitary. Certain trapping data obtained during this study are of interest in this connection. In only one case were two *Geomys* trapped from the same burrow. These were a reproductively active male and a post-partum female caught in April. In 14 instances the presence of at least two individuals in a burrow system was indicated by the fact that an animal was caught in one trap while the second trap of the pair was sprung or blocked with dirt. The reproductive status of the animals caught under these circumstances and the month of capture are as follows: immature female (March), immature female, male, and post-partum female (May), pregnant and post-partum female (July), two immature males and a post-

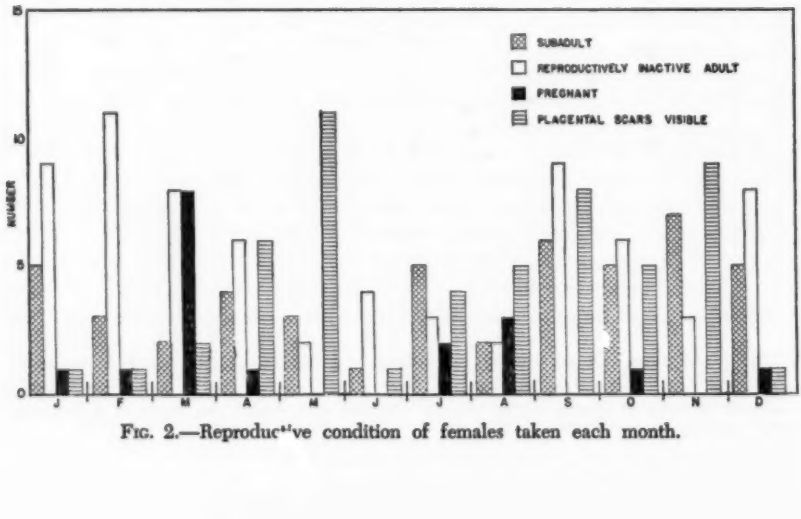


FIG. 2.—Reproductive condition of females taken each month.

partum female (October), and two fertile males (December). The young animals may have been members of family groups that had not yet broken up. The adult captures may indicate that there is more association between individuals, aside from breeding activity, than is commonly thought.

FECUNDITY

Litter size.—Counts of embryos and placental scars were employed to provide data on litter size. Of 19 gravid females caught, nine contained a single embryo and 10 two embryos. The largest embryo obtained weighed 3.8 gms. and had a crown-rump length of 39 mm. This specimen was apparently near term, as Barrington (1940) reported a weight of 5.1 gms. as the average of three newborn young of this species. The smallest uterine swelling recorded was 7 mm. in diameter. Of the pregnant females reported by Barrington (1940) six had a single embryo, four had two embryos, and two had three embryos. Combining these data for 31 females, a mean number of 1.52 ± 0.11 embryos per female is obtained.

Five (10 per cent) of the 29 embryos examined in this study and the 20 reported by Barrington were resorbing. This includes one embryo stated by Barrington as being abnormal. This estimate of the extent of resorption may be low, since embryonic death may be higher at stages earlier than those where it can be recognized grossly.

Placental scars in 60 females ranged from one to five, with a mean of 1.73 ± 0.09. Although two sets of placental scars were discernible in seven uteri, only recent scars were included in the counts. This was done to avoid the possibility of error introduced by the overlapping of the placental scars of different litters. The difference between the mean number of embryos and that of placental scars is not significant ($P = 0.14$). Applying an estimated 10 per cent resorption to the placental scar data results in a calculated litter size of 1.55, which agrees closely with the actual mean number of embryos found.

It appears that *Geomys pinetis* has the smallest litter size of any species of *Geomys* or *Thomomys* yet reported. Numbers of embryos ranging from three to ten have been reported in *T. townsendi* (Horn, 1923) and four to nine in *T. quadratus* [= *talpoides*] (Wight, 1930). In *Geomys breviceps* and *G. b. brazensis* mean litter sizes of 2.36 and 2.66, respectively, have been given by English (1932) and by Wood (1949).

Number of litters per year.—From one to three litters per year have been reported in various species of midwestern and western pocket gopher (Miller, 1946; Wight, 1930; Wood, 1949). At least two litters per year are produced by some *Geomys pinetis* females. Evidence of this was the occurrence of two sets of placental scars, indicating two successive litters at no great interval, in seven specimens examined. Two such cases were recorded in April, three in May, one in June, and one in July. In addition, a pregnant female collected in April had a uterine swelling in the left uterus and a placental scar in the right.

Wood (1949) and Scheffer (1938) have used the brood factor as a measure

of productivity in the pocket gophers. This index is calculated by adding the percentages of field pregnancies at intervals the length of the gestation period, (approximately one month) and dividing by 100. A brood factor calculated in this manner for the southeastern pocket gopher equals 1.15, indicating a lower productivity than the 1.31 to 2.8 determined for *G. breviceps* (Wood, 1949) and *T. bottae* and *T. perpallidus* (Scheffer, 1928).

SUMMARY

The southeastern pocket gopher, *Geomys pinetis*, was studied within a 15-mile radius of Gainesville, Alachua County, north-central Florida. Three hundred and twenty-five specimens were collected and examined from July 1956 through June 1957.

Two major age classes were recognized: adults and immatures. Immature animals were further subdivided into subadults and juveniles on the basis of size and pelage characteristics.

Size and appearance of the reproductive organs were used to determine the reproductive status of females. The estrous condition in the female was indicated by enlarged and turgid tubal genitalia and conspicuous follicles in the enlarged ovary. In contrast, the anestrous condition was characterized by a relatively small flaccid vagina and uterus and a closed vulva. The immature females had uteri less than 27 mm. in length and 1.5 mm. in width, a complete pubic symphysis, and tiny teats.

Morphological indicators of breeding in the male were enlarged testes, the presence of sperm in the cauda epididymis, and turgid and translucent seminal vesicles. Sexually inactive adults and prepubertal males were characterized by the absence of sperm in the cauda epididymis, the tubules of which were microscopic. The testes and seminal vesicles of immature males were smaller than those of regressed adults.

Collected were 325 specimens consisting of 134 males and 191 females, a sex ratio of 41 per cent males. The age ratio of the total sample was 76 per cent adults, 16 per cent subadults, and 8 per cent juveniles.

Breeding is apparently continuous throughout the year, although intensified at certain seasons. Greatest reproductive activity in males seemed to occur from January through August, whereas two breeding peaks, March and July–August, were evident from data for females. Circumstantial evidence suggested that males and females may not become mature until at least six months of age.

The mean number of embryos per pregnant female was 1.52 ± 0.11 and the mean number of placental scare per post-partum female, 1.73 ± 0.09. An incidence of resorption of at least 10 per cent was indicated. Some females were known to have borne at least two litters per year.

ACKNOWLEDGMENTS

I wish to express my indebtedness to James N. Layne, Department of Biology, University of Florida, for his innumerable helpful suggestions and valuable advice and criticism throughout the course of this work. Thanks are also due for the encouragement and guidance given by J. C. Dickinson, Jr., and A. F. Carr, Department of Biology, and R. A. Edwards, Department of Geology, University of Florida.

LITERATURE CITED

Barrington, B. A. 1940. The natural history of the pocket gopher. Unpublished M.S. Thesis, University of Florida. 49 pp.

Bond, R. M. 1946. The breeding habits of Thomomys bottae in Orange County, California. Jour. Mamm., 27: 172–174.

English, P. F. 1932. Some habits of the pocket gopher, Geomys breviceps breviceps. Jour. Mamm., 13: 126–131.

HILL, J. E. 1937. Morphology of the male pocket gopher, mammalian genus *Thomomys*. Univ. Calif. Publ. Zool., 42: 81–171.

HISAW, F. L. 1923. The influence of the ovary on the resorption of the pubic bones of pocket gopher (*Geomys bursarius*). Jour. Exp. Zool., 42: 411–441.

———. 1932. The adsorption of the pubic symphysis of the pocket gopher, *Geomys bursarius* (Shaw). Amer. Nat., 58: 93–96.

HORN, E. E. 1923. Some notes concerning the breeding habits of Thomomys townsendi, observed near Vale, Malheur County, Oregon, during the spring of 1921. Jour. Mamm., 4: 37–39.

MILLER, M. A. 1946. Reproductive rates and cycles in the pocket gopher. Jour. Mamm., 27: 335–358.

SCHEFFER, T. H. 1938. Breeding records of the Pacific Coast pocket gopher. Jour. Mamm., 19: 220–240.

SHERMAN, H. B. 1936. List of the Recent wild land mammals of Florida. Proc. Florida Acad. Sci., 1: 102–128.

WOOD, J. E. 1949. Reproductive pattern of the pocket gopher (*Geomys breviceps brazensis*). Jour. Mamm., 30: 36–44.

WIGHT, H. M. 1930. Breeding habits and economic relations of the Dalles pocket gopher. Jour. Mamm., 11: 40–48.

Dept. of Biology, Univ. of Florida, Gainesville. Received 3 September 1958.

CYCLIC CHANGES IN THE MORPHOLOGY OF THE VULVA AND CLITORIS OF *DIPODOMYS*

BY E. W. PFEIFFER

Recent reports on reproduction in the female *Dipodomys* (Fitch, 1948; Holdenried, 1957; Pfeiffer, 1956, Day *et al.*, 1956) describe prominent changes in the size and appearance of the vulva, and indicate that these changes occur regularly in wild animals. The reports, however, differ in their interpretations of the relationship of these changes to the female sexual cycle. This report describes observations made on reproduction of both wild and captive female *Dipodomys*, and points out certain relationships of vulval morphological changes to the sexual cycle.

Because the clitoris also changes cyclically, observations on its structure are included in this report. The clitoris of *Dipodomys* is a penis-like organ, about 3 mm. long, and similar to that described in certain insectivores and primates (Godet, 1950; Peyre, 1955; Jones, 1914). The clitorine (cavernous) urethra conducts urine to the tip of the clitoris. It joins the membranous portion of the urethra distally to a sac-like dilatation of its proximal end (Plate I, A). The clitorine urethral epithelium (C.U.E.) undergoes prominent cyclical morphological changes as described below, but the epithelium of the membranous urethra does not show such changes.

METHODS AND OBSERVATIONS

Untreated females.—In this study, ninety-one adult wild female *Dipodomys ordi* were captured at different times of the year and examined. Thirty-one were killed and autopsied immediately after capture, and reproductive organs were prepared for histological study. Nine females were pregnant, or had recently ovulated and their vulvas were small, and the vaginal orifices were almost completely obliterated. Histological sections showed that the epithelium of the vagina was a thin, stratified squamous, non-cornified type which formed cords of cells radiating from a slit-like lumen. The C.U.E. was similar to that of the vagina (Plate I, *C*). The ovaries of these females had large corpora lutea, several small vesicular follicles, and atrophic, chromophobic, interstitial cells. (The ovarian interstitial cells of *Dipodomys* apparently are derived from the theca interna of atretic follicles.)

Five females possessed inactive reproductive tracts and will be referred to below as anestrous females. Their vulvas and vaginas resembled those of pregnant females, but the ovaries were smaller than those of progestational females and contained no vesicular follicles or corpora lutea. There was hypertrophy of interstitial cells in some specimens. In all anestrous females the C.U.E. was thrown into deep folds and consisted of a thick, stratified layer of hypertrophied, squamous, non-cornified cells, some of which were desquamated into the urethral lumen (Plate I, *D*).

Seventeen of the wild females possessed vulvas that exhibited different degrees of swelling with a maximum vulval diameter of 11 mm. in one specimen.

In some of these females the vulval mucosa was turgid, moist, and hyperemic, and the expanded vaginal lumen was lined by a thick, cornified, stratified squamous epithelium (Plate I, *E*). The ovaries of these females contained several large vesicular follicles. In other females with swollen vulvas the mucosa was pale and dry with much desquamation of the superficial cornified cell layers. Their vaginal epithelium was thin, and there was leucocytic infiltration into the lumen. These females had many mitotic figures but little or no vesicle formation in the ovarian follicles, and evidence of follicular atresia was often seen. Chromophobic ovarian interstitial cells were hypertrophied in some females with swollen vulvas (Plate I, *B*), but not in others.

Sixty isolated females were observed daily in the laboratory (for long periods prior to the experiments described below). Their vulvas often remained swollen for many weeks during the seasons in which sexual activity has been recorded for wild individuals of this species (Duke, 1944). At other times the vulvas

A, Sagittal section of clitoris and vagina of an anestrous, intact female *Dipodomys* showing junction of membranous urethra (*UG*) with clitorine urethra (*U*); *V* = vagina. *B*, Ovary of untreated female with swollen vulva showing hypertrophied, chromophobic interstitial cells. *C*, X-section of clitoris and vagina of pregnant female at junction of *UG* and *U*. *D*, X-section of clitoris and vagina of anestrous female at junction of *UG* and *U*. *E*, X-section of clitoris and vagina of intact, untreated, captive female with swollen vulva at junction of *UG* and *U*. *F*, Vaginal mucosa of intact female injected with human pregnancy urine when her vulva was swollen. *B* and *F*, × 65; all others, × 18.

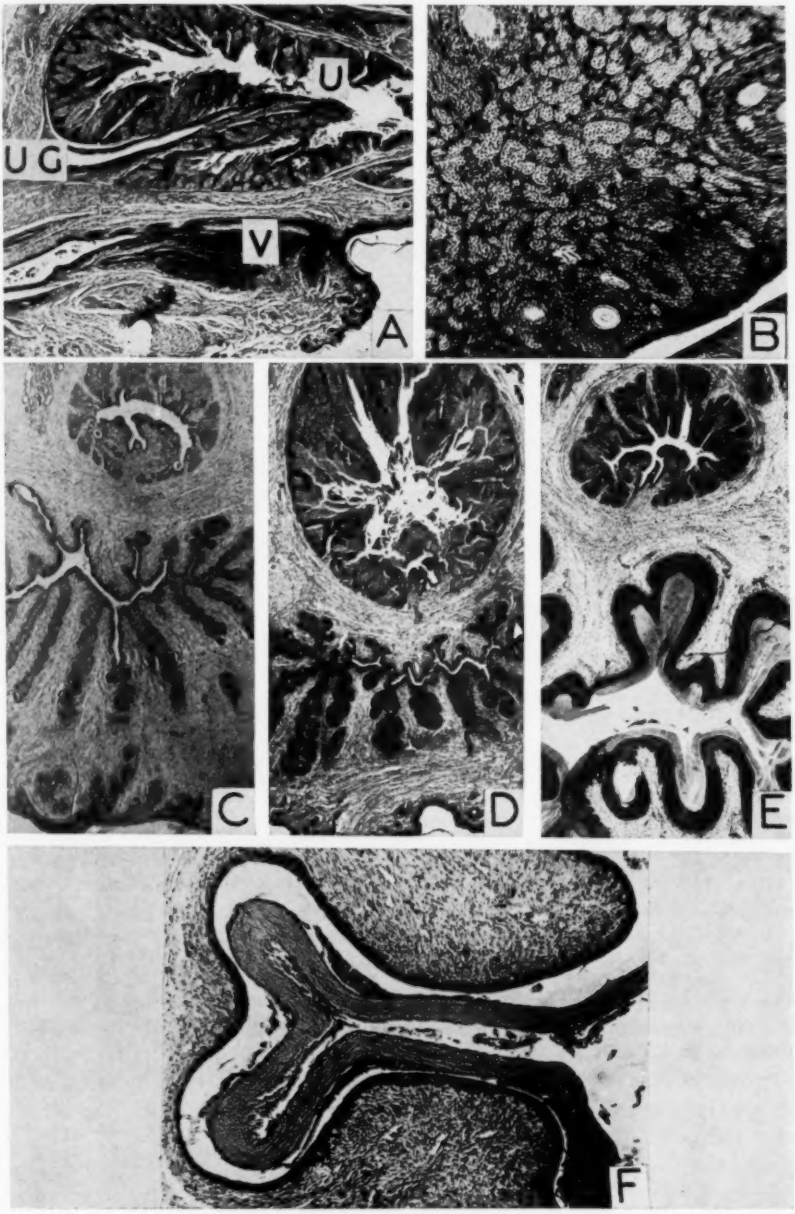


PLATE I — legend opposite

were small, and their orifices were closed. The mucous membranes of the swollen vulvas underwent periods of turgidity and hyperemia followed by blanching of the mucosa and desquamation of superficial epithelial cells. Eleven untreated females were killed after long periods of captivity. In this group were anestrous females, females with swollen vulvas, and post-ovulatory females. The morphology of the vulvas, clitorises, vaginas, and ovaries of these captive females was the same as that of the previously described wild females in similar phases of the sexual cycle.

Experimental females.—In order to experimentally determine the relation of the condition of the vulva, vagina, and clitorine urethra to ovarian function, captive females were injected with different hormones. Thirty-two of the sixty captive females were injected with gonadotropins (2 cc. untreated human pregnancy urine or 10–500 I.U. Gonadogen and/or Chorionic Gonadotropin, Upjohn) for three days. At autopsy two or three days after the last injection, the ovaries were enlarged and contained many large vesicular follicles, some with luteinized granulosa cells. The interstitial cells were hypertrophied and eosinophilic. Ovulation apparently did not occur in these females. In females with swollen vulvas, the gonadotropins caused a rapid decrease in size of the vulva, desquamation of the superficial cornified layer of vaginal epithelium, and leucocytic infiltration of the remaining strata of squamous cells and of the vaginal lumen (Plate I, *F*). Gonadotropins had no effect on the C.U.E. of these females.

Gonadotropins injected into anestrous females caused opening of the vaginal lumen and moderate swelling (6–8 mm. in diameter) and much hyperemia of the vulva and entire perineum. The vaginal epithelium of these females was thickened, cornified, and hyperplastic, but there was a decrease in thickness of the C.U.E. Desquamated epithelial cells were present in the clitorine urethral lumen.

To further study the relationship of ovarian function to the condition of the vulva and clitoris, many females were ovariectomized. Three of these animals were autopsied several weeks after ovariectomy and their vulvas, vaginas, and C.U.E. were found to be similar to those of anestrous females.

Eight ovariectomized females were treated with estrogen (0.01 mg/day Progynon B, Schering, for 3 days) and/or progesterone (2.5 mg/day Proluton, Schering, for 3 days). Injections of estrogen caused swelling and hyperemia of the vulva, proliferation and cornification of the vaginal epithelium, but superficial desquamation and thinning of the C.U.E. Estrogen applied by inunction to one ovariectomized female caused swelling of the vulva but had no effect on the greatly thickened and hypertophied C.U.E. Estrogen and progesterone together and progesterone alone appeared to have little effect upon the vulva or C.U.E. of ovariectomized females.

Estrogen injected into four intact, anestrous females produced vulval and clitorine urethral responses similar to those described for ovariectomized females. Progesterone, however, injected into two intact females with swollen

vulvas produced a rapid decrease in size of the vulva. The other organs were not examined in these two specimens. These results are similar to those of Hammond (1951) studying the ferret vulva and of Hisaw *et al.* (1937) studying the sexual skin of monkeys. Berthelsen (1958) found that estrogen injected into male rabbits caused an increase in cells and a change in cell types present in urethral smears, while androgens did not alter the smears as compared with controls. It therefore appears that estrogen stimulates the penile urethral epithelium in rabbits.

DISCUSSION

These experiments demonstrate that estrogen causes vulval swelling and reduction in thickness of the C.U.E., and that progesterone inhibits these actions of estrogen. Exogenous gonadotropins injected into intact females may inhibit or promote vulval swelling depending on the condition of the ovary at the time of treatment, and they cause thinning of the C.U.E. as a result of ovarian stimulation.

The above observations indicate that in intact, untreated females the vulva enlarges during proestrous ovarian follicular development and may remain enlarged for long periods when proestrous growth and atresia of ovarian follicles are occurring. The vulva decreases in size rapidly after ovulation and remains small during arrested follicular development in anestrous females. The C.U.E. is thin and atrophic during periods of greatest ovarian activity but is greatly thickened and the cells are hypertrophied during the anestrous phase of the ovarian cycle. This epithelium must be stimulated by an extraovarian principle which appears to be inhibited by ovarian secretions produced during the proestrous, estrous, and luteal phases of the cycle in untreated females. The presence of hypertrophied interstitial cells in the ovary is not correlated with hypertrophy and hyperplasia of the vaginal or clitorine urethral epithelium.

SUMMARY

The vulva of *Dipodomys ordi*, as observed in specimens killed immediately after capture and in intact, untreated specimens maintained in the laboratory, enlarges during proestrous ovarian follicular development and may remain enlarged for long periods. Ovulation results in rapid involution of the vulva, as does cessation of ovarian activity.

The epithelium of the clitorine urethra is greatly thickened during anestrus but is thin and atrophic during periods of greatest ovarian activity.

In experimental animals, ovariectomy caused involution of the vulva and thickening of the clitorine urethral epithelium. Estrogen produced swelling of the vulva and thinning of the clitorine urethral epithelium. Progesterone inhibited these actions of estrogen. Exogenous gonadotropins injected into intact females caused limited vulval swelling in anestrous females and rapid involution of the swollen vulva in proestrous females. Gonadotropins also produced thinning of the clitorine urethral epithelium in intact, anestrous females.

ACKNOWLEDGMENTS

This investigation was supported, in part, by grants from the National Institutes of Health and from the Utah State Agricultural College. The gonadotropic hormones and the steroid hormones were generously supplied by Dr. M. E. Speeter, Upjohn Company, and Dr. G. K. Hawkins, Schering Corporation, respectively. I also wish to thank Dr. T. L. Bahler, Utah State University, for material assistance in the course of this work.

LITERATURE CITED

BERTHELSEN, H. G. 1958. Changes in the urethral smear in the male rabbit following the administration of estrogens. Acta Endocrin., 28: 375–380.

DAY, B. N., H. J. EGOSCUE, AND A. M. WOODBURY. 1956. Ord kangaroo rat in captivity. Science, 124: 485–486.

DUKE, K. L. 1944. The breeding season in two species of *Dipodomys*. Jour. Mamm., 25: 155–160.

FITCH, H. S. 1948. Habits and economic relationships of the Tulare kangaroo rat. Jour. Mamm., 29: 5–35.

GODET, R. 1950. La differenciation du sexe chez la taupe. Arch. Anat. Microsc. Morph. Exper., 39: 627–633.

HOLDENRIED, R. J. 1957. Natural history of the bannertail kangaroo rat in New Mexico. Jour. Mamm., 38: 330–350.

HAMMOND, J., JR. 1951. Effects of androstenedione and progesterone on estrous swelling of the ferret vulva. Jour. Endocrin., 7: 173–176.

HISAW, F. L., R. O. GREEP AND H. L. FEVOLD. 1937. The effects of oestrin-progestin combinations on the endometrium, vagina and sexual skin of monkeys. Amer. Jour. Anat., 3: 483–503.

JONES, F. W. 1914. The morphology of the external genitalia of the mammals. Lancet, 186: 1099–1103.

PEYRE, A. 1955. Intersexualité du tractus genital femelle du desman des Pyrenées (*Galemys pyrenaicus* G.). Bull. Soc. Zool. France, 80: 132–138.

PFEIFFER, E. W. 1956. Notes on reproduction in the kangaroo rat (*Dipodomys*). Jour. Mamm., 37: 449–450.

Dept. of Anatomy, Univ. of North Dakota, Grand Forks. (Present address: Dept. of Zoology, Montana State Univ., Missoula.) *Received 14 July 1958.*

LIFE HISTORY NOTES ON MERRIAM'S KANGAROO RAT IN SOUTHERN ARIZONA

BY HUDSON G. REYNOLDS

During an ecological investigation of Merriam's kangaroo rat, *Dipodomys m. merriami* Mearns, in southern Arizona (Reynolds, 1958) considerable data were collected on life history. This paper discusses aspects of reproduction and development, breeding habits, activity patterns, and home range.

Grateful acknowledgment is made to Horace S. Haskell, formerly of the University of Arizona, who assisted in the collection of field data, and to A. Starker Leopold of the University of California, who offered helpful suggestions in the preparation of the manuscript. Most of the work was undertaken while the author was Assistant Range Ecologist with the Arizona Agricultural Experiment Station. Raymond Price, of the Rocky Mountain Forest and Range Experiment Station, made the Santa Rita Experimental Range available for studies.

Most of the observations were made on the Santa Rita Experimental Range.

STUDY AREA

This area of about 60,000 acres is located about 40 miles south of Tucson, Arizona.

Environmental conditions on the experimental range extend from the creosote desert at 3000 feet elevation with an annual rainfall of about 9 inches to the oak-woodland at 4500 feet elevation with an annual rainfall of about 20 inches. Mean monthly temperatures vary from 47° in January to 85°F. in July. Seasonally, relatively high temperatures coincide with comparatively high rainfall in the summer, low rainfall with intermediate temperatures in the fall and spring, and low temperatures with intermediate rainfall during the winter. These climatic conditions result in two growth periods for plants. One group of plants matures during the spring, the other during late summer.

The Experimental Range has been grazed by controlled numbers of cattle since 1915. Differences in altitude, soil and grazing use result in a wide variety of plant communities.

DEVELOPMENT AND BEHAVIOR

Development.—Pregnant females were captured in the field during the breeding season and kept in artificial nests until they bore young. In June 1943, growth of two young was carefully observed in captivity. Parturition took place outside the nesting box. The young were born head first. They were hairless and the skin was light pink in color. Pigmentation first appeared on the second day and was completed by the eleventh day. The only unpigmented areas remaining were the undersides and those areas over the hips and around the eyes and ears that correspond to the white markings of mature animals.

Except for the vibrissae, which were 4–6 mm. long at birth, no hair appeared on the young animals until the fourth day after birth. By the eighth day, fine hair completely covered the body (Plate I); at two weeks, the pelage was comparable to that of mature rats.

Eyes were closed at birth, but marked by a shallow horizontal groove. The eyelids separated along this groove at 13 days of age; by 17 days the eyes were fully open.

Incisors did not break through the gums until the eighth day. External cheek pouches were merely folds of skin at birth. They gradually deepened and were first used at 18 days of age.

At birth the animals were nearly helpless; for about one week they moved only by crawling. By 11 days, hind legs were fully functional and the animals became very active. At two weeks the bipedal form of locomotion was used exclusively.

Up to 13 days, the young came out of the nest whenever an observer approached; by 17 days, they were nocturnal only.

Until about two weeks of age young animals were almost wholly dependent upon the mother for food and protection. After ten days, however, they took solid food. Young animals continued to supplement their rolled barley diet

TABLE 1.—*Average growth measurements of three pairs of Merriam kangaroo rat litter mates; averages were taken from least-squares freehand curves*

AGE IN WEEKS	BODY MEASUREMENTS, MM.				WEIGHT, GM.
	Hind foot	Ear	Tail	Body	
Birth	12	1.5	15.0	42.5	4.0
2	27	4.5	60.0	52.5	10.0
4	34	8.5	100.0	75.0	18.0
6	35	9.5	122.5	82.5	24.0
8	35	9.5	130.0	85.0	28.0
10			132.5	90.0	31.0
12			132.5	95.0	34.0
14				97.5	36.0

by nursing until three weeks of age. They were transported by the nape of the neck between the teeth of the mother (Plate I). If molested at any time in the cage, they were quickly picked up and carried into the nesting box.

Growth.—Between birth and an age of 15 weeks, measurements were made at weekly intervals on three pairs of litter mates. The errors in measuring live animals were reduced to a minimum by repeating measurements until a consistent value was obtained. Growth values for individual animals were plotted on graph paper, a least-squares freehand curve was fitted to these observations, and average measurements were read from the curve (Table 1).

Full development of ears and hind feet was reached within a period of six weeks after birth. Tails attained complete elongation at an age of 10 weeks. Body lengths increased rapidly for about four weeks, although they were still growing slowly at 14 weeks when measurements were terminated. Body weights were still increasing at 14 weeks. Field measurements suggest that complete body length and weight are not reached until an age of about five months.

Behavior.—The behavior of several nursing females was noted with respect to nest and young. Burrow entrances were plugged by the mother as she left the nest for her nightly foraging activity. All released females dug back

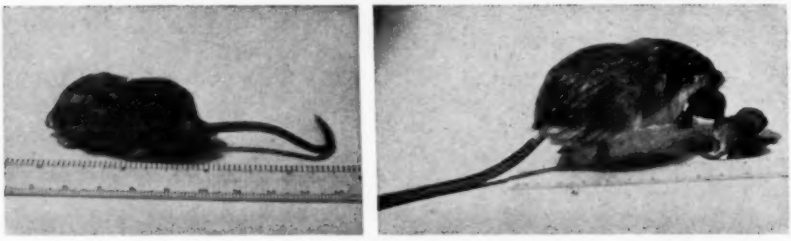


PLATE I

LEFT: A fine hair comparable in arrangement to the pelage of mature animals appears in about a week. RIGHT: Young animals are transported by the nape of the neck between the teeth of the mother.

into the home burrow to reach the young. One even avoided the plugged openings and dug a new opening into the burrow system. Plugging the burrow may be partly a device for preventing emergence of the young. In excavated burrows young animals were often found several feet from the nest. If openings had not been plugged, young might have wandered from the protection of the burrow.

The behavior of one female within the area of her burrow system illustrates the general pattern noted. When first released, she took refuge in a burrow that was apparently used as a daytime retreat. Average depth was about 6 in. and maximum depth about 10 in. Although a simple tunnel, the burrow was deep enough to afford adequate protection from daytime temperatures. Average maximum soil surface temperatures in June in this region may exceed 140°, as air temperatures reach 95°F. Burrow temperatures at this time are about 60° less than those of the soil surface and 10° less than those of the air (Vorhies, 1945). Moreover, burrow humidity remains low enough to create a favorable water balance as a result of metabolic water formation (Schmidt-Nielsen and Schmidt-Nielsen, 1952).

When excavated from the first burrow, this female tried to return but finally entered another, evidently the main burrow as it contained a nest chamber and there was evidence of considerable food waste. The main tunnel of this burrow extended to a depth of 13 in. During the morning of excavation, repeated returns were made to this main burrow. Two additional escape burrows completed the burrow system of this particular rat.

Nests and nesting chambers were crudely constructed, usually in an enlarged portion of the main tunnel. They consisted mostly of stems of annual grama (*Bouteloua aristidoides*) or plaintain (*Plantago* spp.) neatly piled together.

The youngest animals taken by snap-trapping in the field were about three to four weeks of age. This was one to two weeks after the young were independent of the mother, and about one week after the eyes and ears become fully functional.

Size at maturity.—External measurements were recorded for over 1,100 animals captured by snap-trapping. Maturity of animals was based upon field observations of weight, size and pelage. Decision as to whether an individual should be classed as an adult or subadult was often arbitrary.

Average size of 644 adult males was: Total length, 239.5; tail, 140.1; and foot, 37.1 mm. Respective sizes of 482 adult females were 235.9, 137.4, and 36.6 mm. Difference between males and females in length of body and tail is statistically significant but difference in length of foot is not.

Weights of mature rats varied with season of the year (Fig. 1). Weights were lowest during winter when food was relatively scarce and highest during the summer growing season of August and September.

Weight differences between the sexes were statistically significant throughout the year. Variation of individual weights, however, does not permit segregation of sexes on this basis. The lower weight of females is a reflection of their

smaller size. Pregnant females averaged about 2.5 gm. heavier than non-pregnant females. This is close to the average difference of 3.6 gm. between sexes for all months.

BREEDING ACTIVITIES

The external genitalia of both sexes change conspicuously at the beginning of the breeding season. The testes shift from an inguinal to a scrotal position and become much enlarged. External genital organs of females also change. During estrus, the region around the clitoris becomes swollen. The lips of the vaginal opening become enlarged and folded. With waning of estrus the reverse process takes place until the vaginal opening is closed and inconspicuous. In ascertaining the duration and intensity of the breeding season, only the evidence of scrotal testes or macroscopic embryos was considered.

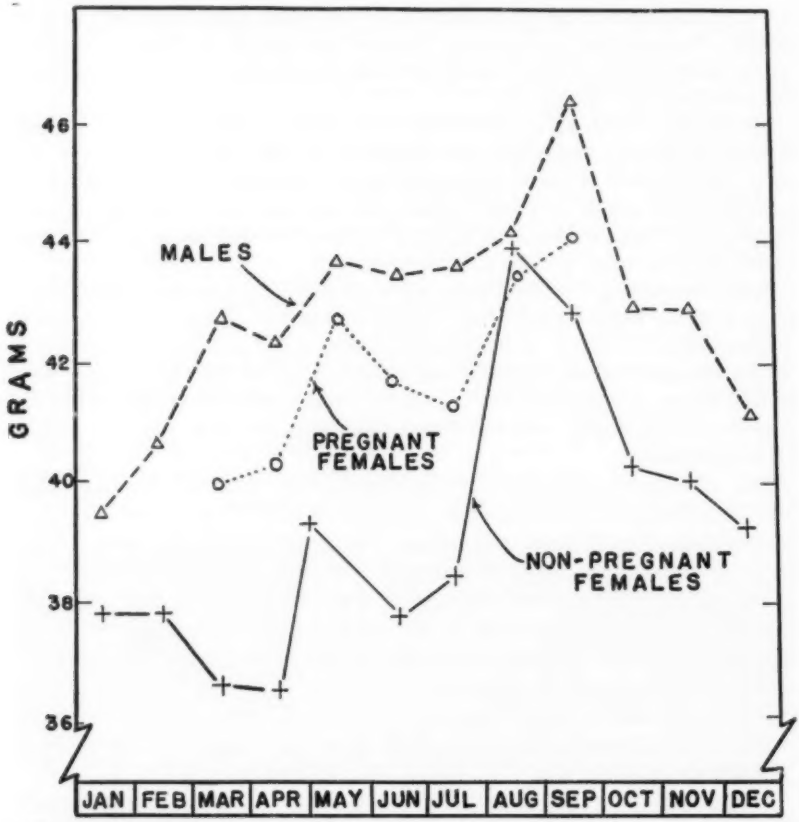


FIG. 1.—Monthly weight changes of adult Merriam kangaroo rats on the Santa Rita Experimental Range.

Merriam kangaroo rats breed before reaching adult weight. Several pregnant females of about 70 per cent mature weight were taken in August. Estrus among subadult females was also observed in late fall. A number of males

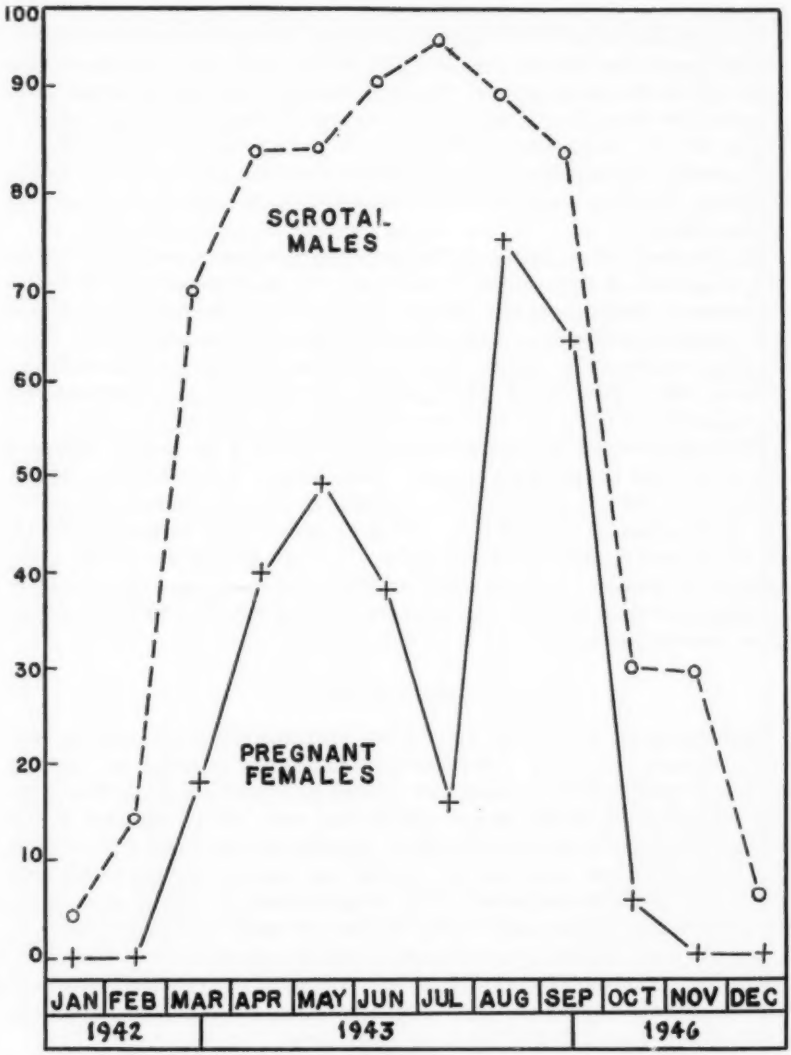


FIG. 2.—Composite of the years 1942, 1943 and 1946, showing the percentage of scrotal male and pregnant female Merriam kangaroo rats in the adult population observed each month.

of subadult weight, with scrotal testes, were captured in both July and August. These animals, judging from age-size relations, were born the previous March and April. Young animals thus appear to breed within the year of their birth. Fitch (1948) noted that *D. heermanni* showed evidence of estrus at two months of age.

Breeding season.—On the experimental range, Merriam rats breed over the greater part of the calendar year (Fig. 2). Of 606 males examined there were some with scrotal testes in every month of the year. Per cent of scrotal testes dropped to 4 during the winter months as compared with 97 during the summer. Among 458 females examined, pregnancies were first noted in March, showed peaks during May and September, and fell to zero during the winter. A similar two-phase breeding season has been observed in *D. ordi* and *D. microps* (Duke, 1944).

The two peaks of pregnancy in Merriam kangaroo rats corresponded closely with the periods of new vegetative growth of spring and late summer. Whether the relation is one of cause and effect is problematical. There is some evidence that nutrients contained in fresh vegetation have a stimulating effect upon breeding activity. The estrous cycle of *Microtus guentheri* seems to be associated with a gonadotropic factor found in fresh green plant material that is responsible for increased ovulation (Bodenheimer and Sulman, 1946).

Litter number and frequency.—Number of embryos per female averaged 2.02 (1 to 3) for 133 pregnant animals. These females were taken from March through October. Average number of young per female during this period was fairly consistent, varying from 1.50 in October to 2.18 in September. Of the 133 females examined, 125 had embryos in each horn of the uterus. Only eight of the females contained single embryos and these were about equally distributed between the right and left horn. Twelve females had two embryos in one horn of the uterus.

DAILY ACTIVITY

Observations on the activity of Merriam kangaroo rats were made in captivity. Animals were confined to cages of about 25 sq. ft. provided with nesting boxes and feeding trays. Cages were placed in a shed for protection from high insolation. A treadle was so placed that each exit or entrance to the nesting box was recorded on a time-clock recording device. Thus, both amount of activity (trips per hour over the treadle) and amount of time outside the nesting box could be computed. Daily measurements of activity were made for four females and one male during the last two weeks of August 1946.

Animals were strictly nocturnal; rarely did an animal venture out of its nesting box during daylight. Such a daylight trip usually was caused by unusual noise or activity around the box. Confinement of above-ground activity to nightly hours was verified by all field observations.

Frequent trips were made between nesting box and feeding tray during the course of a night (Fig. 3). Activity did not begin before 6:00 PM and

ceased completely by 7:00 AM. Official sunrise time for August was about 5:50 AM and sunset about 7:00 PM.

Two peaks of activity occurred in terms of per cent of time outside the nesting box. The first peak was reached at 9:00 PM, the second at 4:00 AM. Merriam rats seldom spend more than 35 per cent of any hour outside of the nesting box even during periods of maximum activity. Such bimodal nocturnal pattern of activity has also been observed in other rodents, e.g., *Micotrus* (Hamilton, 1937), *Neotoma* (Spencer, 1941), and *Sigmodon* (Calhoun, 1945).

SPATIAL RELATIONS

Two quadrats in the mesquite-burroweed type of vegetation, each approximately 7 acres, were live-trapped during the summers of 1942 and 1946. Individual home ranges of marked animals were determined by plotting trap locations on graph paper and drawing lines around the traps in which each individual was taken. A home range was considered as the enclosed space occupied by used traps, plus one-half the distance to the closest unused trap. Areas of individual home ranges were computed by planimeter. Only those ranges completely within the quadrats were included in computations. Quadrats were trapped over a period of one month.

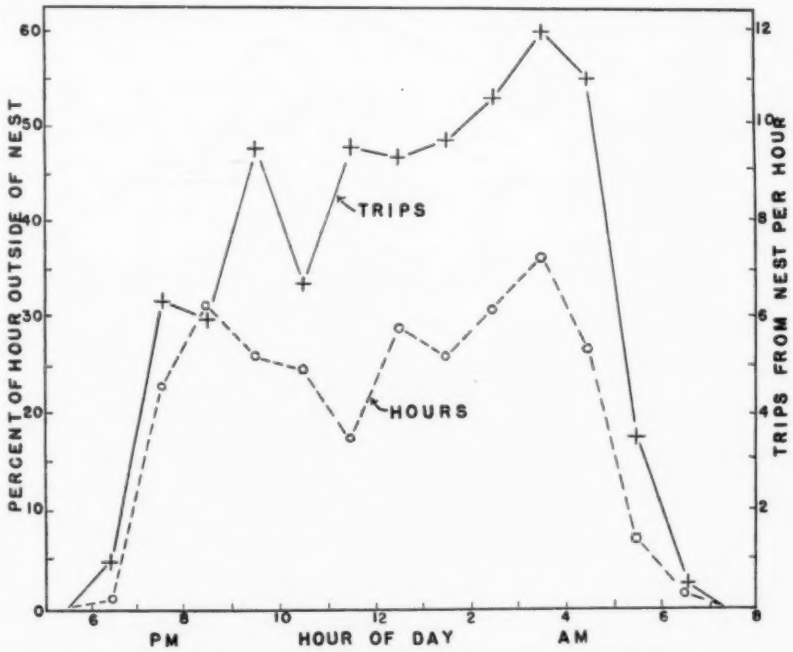


FIG. 3.—Daily activity of the Merriam kangaroo rat in captivity.

Home range.—The differences in size of home ranges in different years were not statistically significant (Table 2), but differences in size of ranges of adults and immature animals were highly significant. Males and females differed in amount of home range occupied in 1946 but not in 1942. Because of improved technique and greater experience in 1946, and hence greater reliability of the data, adults were considered to occupy home ranges of different sizes.

Average size of home ranges in acres for all years was: 0.466 for adult males; 0.373 for adult females; and 0.243 for immature animals irrespective of sex. Assuming home ranges to be most nearly circular in outline, their average radius (in feet) would be: 80 for adult males, 72 for adult females,

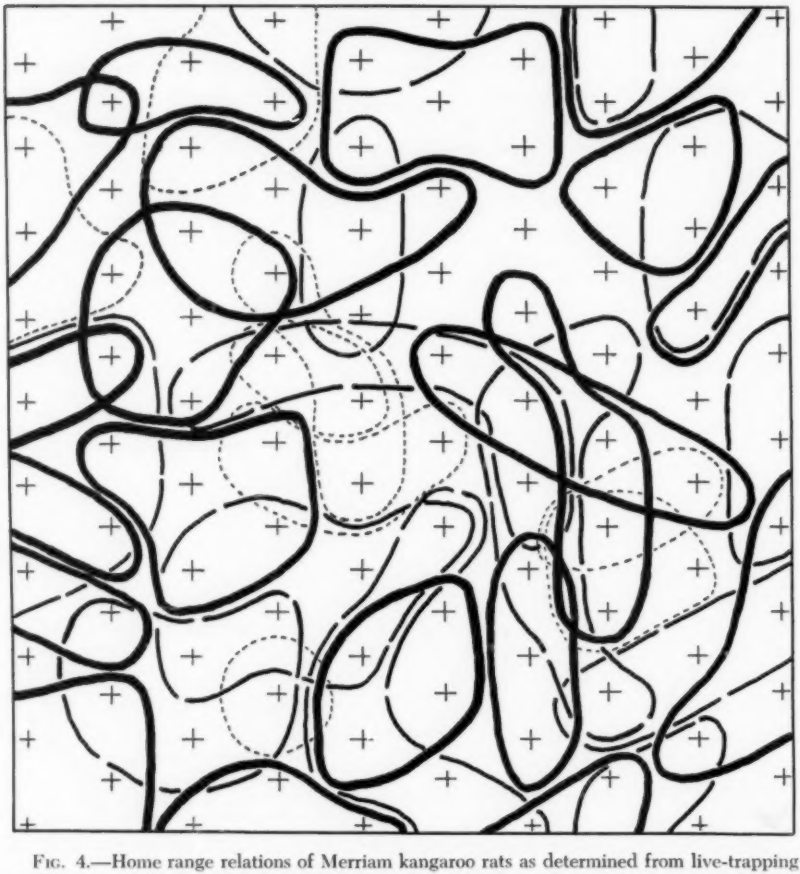


FIG. 4.—Home range relations of Merriam kangaroo rats as determined from live-trapping at 7.5-acre quadrat on the Santa Rita Experimental Range during the summer of 1946. Solid lines—adult females; dash lines—adult males; dotted lines—immature animals.

TABLE 2.—*Average home ranges occupied by adult male, adult female, and immature Merriam kangaroo rats during June 1942 and 1946*

YEAR	AGE	SEX	NUMBER	AVERAGE AREA, ACRES
1942	Adult	♂	6	0.463 ± .044
	Adult	♀	6	0.376 ± .034
	Immature	♂,♀	8	0.266 ± .023
1946	Adult	♂	5	0.469 ± .029
	Adult	♀	7	0.371 ± .032
	Immature	♂,♀	6	0.212 ± .021

and 58 for immature animals. Blair (1943) found that *D. merriami* males occupied 4.07 ± 0.24 acres and females 3.88 ± 0.51 acres.

Territories.—Females, during the breeding season, appeared to occupy territories to the virtual exclusion of other members of the same sex (Fig. 4). Home ranges of females seldom overlapped at more than one trap station. Individual males occupied home ranges that not only overlapped those of females, but also of other males. Centers of male home ranges, however, seemed to be located away from each other. Immature animals tended to take up areas not occupied by adults. Also, more home ranges of immature animals were located within home ranges of adult females than of adult males.

SUMMARY

Life history information for Merriam's kangaroo rat, *Dipodomys m. merriami*, in southern Arizona is reported. In this region the climate is arid. Soils are poorly developed. The vegetation is composed of desert shrubs, drought-resistant, summer-growing perennial grasses, and annual plants some of which mature in the spring, others in the summer.

Body measurements reach mature proportions in the following lengths of time: ear and hind foot, about 6 weeks; tail, 10 to 12 weeks; body length, at 15 weeks; weight, from 5 to 6 months. Weights vary greatly with season of the year—from 39.5 to 46.5 grams among males, and from 36.5 to 43.8 grams among females.

Pregnant females were taken in all months except November through February. Pregnancies were most frequent in May and September. Litters average 2.02 (1 to 3) young per female. Per cent of scrotal males in the population varied from 4 in January to 97 in July.

Animals were active throughout the year and were strictly nocturnal in habit. Activity was greatest in the early evening and early morning hours.

Average size of home ranges in acres was: 0.466 for adult males, 0.373 for adult females, and 0.243 for immature animals.

During the breeding season, adult females occupy home ranges (possible territories) to the virtual exclusion of other individuals of the same sex; adult males have slightly larger and more irregular home ranges which overlap ranges of other animals of both sexes.

LITERATURE CITED

BLAIR, W. F. 1943. Populations of the deermouse and associated small mammals in the mesquite association of southern New Mexico. Contr. Lab. Vert. Biol., Univ. Mich., 21: 1–40.

BODENHEIMER, F. S. AND F. SULMAN. 1946. The estrous cycle of *Microtus guentheri* D. and A. and its ecological implications. Ecology, 27: 255–256.

CALHOUN, J. B. 1945. Diel activity rhythms of the rodents, *Microtus ochrogaster* and *Sigmodon hispidus hispidus*. Ecology, 26: 251–273.

DUKE, K. L. 1944. The breeding season in two species of Dipodomys. Jour. Mamm., 25: 155–160.

FITCH, H. S. 1948. Habits and economic relationships of the Tulare kangaroo rat. Jour. Mamm., 29: 5–35.

HAMILTON, W. J., JR. 1937. Activity and home range of the field mouse, *Microtus pennsylvanicus* (Ord). Ecology, 18: 355–363.

REYNOLDS, H. G. 1958. The ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecol. Monogr., 28: 111–127.

SCHMIDT-NIELSEN, K. AND B. SCHMIDT-NIELSEN. 1952. Water metabolism of desert mammals. Physiol. Rev., 32: 135–166.

SPENCER, D. A. 1941. A small mammal community in the upper Sonoran desert. Ecology, 22: 421–425.

VORHIES, C. T. 1945. Water requirements of desert animals in the Southwest. Ariz. Agric. Exp. Sta., Tech. Bull. 107: 487–525.

Museum of Vertebrate Zoology, Univ. of California, Berkeley. Received 28 October 1958.

HABITS OF HARVEST MICE REVEALED BY AUTOMATIC PHOTOGRAPHIC RECORDERS

BY OLIVER P. PEARSON

The information reported here was obtained through the use of two automatic, repeating, photographic recorders operating in mouse runways at Orinda, Contra Costa County, California. The recorders photographed each animal as it passed along a natural runway and they registered at that instant the time, the temperature, and the relative humidity. Many of the mice were live-trapped and marked so that they were individually recognizable in the photographs. The study extended from January 1956 to September 1957. A description of the apparatus, habitat and procedure has been published (Pearson, 1959); an analysis of the data concerning *Microtus* will appear elsewhere (Pearson, 1960).

The recorders were placed at what appeared to be much-traversed *Microtus* runways and, since harvest mice (*Reithrodontomys megalotis*) also used these runways, many records were obtained of their activity. It is probable that less of their activity is restricted to runways than is that of *Microtus californicus*, so the activity of *Reithrodontomys* has probably not been sampled as completely as was the *Microtus* activity.

Amount of activity in a runway.—During 778 recorder-days and nights, 1,753 passages by *Reithrodontomys* were photographed, or 2.25 per 24 hours. During the same period in the same runways traffic by meadow mice averaged 7.8 passages per 24 hours. The traffic by meadow mice, however, was spread throughout the 24 hours whereas that by harvest mice was almost entirely at night. Per night there were about half as many *Reithrodontomys* passages as *Microtus* passages. A predator waiting at night at one of the *Microtus* runways

at which the recorders were placed could have expected a harvest mouse, on the average, every 5.3 hours.

Under favorable circumstances the number of *Reithrodontomys* passages was considerably more than the average 2.25 per night. At one recorder, for example, between 17 September and 6 January there was an average of 6.9 passages per night; extremes during this period were 0 and 27 passages per night. The month of greatest *Reithrodontomys* traffic was October, during which the average nightly traffic at the single recorder operating at that time was 8 passages. Figure 1 shows the average number of passages of harvest mice per recorder for each month.

Effect of rain on activity.—The mean number of passages made by *Reithrodontomys* during 109 rainy nights (2.46 per recorder-night) was slightly greater than the corresponding number of passages on 128 rainless nights within two days of the rainy period (2.37 per recorder-night). When the number of passages per night during each rainy period is subtracted from the number of passages per night during the adjacent rainless nights, and when these differences are analyzed by the Wilcoxon signed rank test, the small average differences between rainy and rainless traffic are found to be statistically insignificant. For these analyses, a night was considered to be rainy if more than a trace of precipitation was recorded at the following 6 PM emptying of the rain gauge at the Orinda Bowman weather station. Obviously a few nights may have been included during which no rain fell, since all of the rainfall recorded at 6 PM may have fallen during the daylight hours after the harvest mice had retired for the day.

On numerous occasions meadow mice with wet fur were recorded, but no photographs were obtained of wet harvest mice.

Effect of phase of moon on activity.—I have compared the number of passages by *Reithrodontomys* on the three nights of fullest moon each month with the number of passages on the five nights of least moon each month. No allowance has been made for cloudy nights, because a cloudy night with full moon is

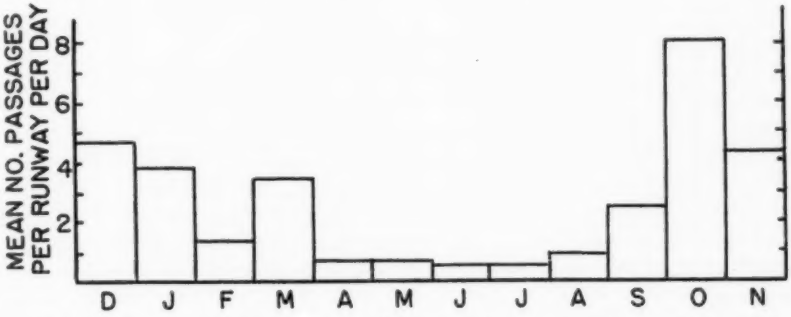


FIG. 1.—Average number of passages of harvest mice per runway per 24 hours for each month.

brighter than a night with no moon. Since the recorders were sometimes moved to a different runway between a full-moon period and the following moonless period two weeks later, thereby introducing the probability that there would be a change in traffic density for reasons unrelated to phase of the moon, I have used only pairs of recording periods, full-moon and the following moonless period, during which there was at least one passage and between which the recorders were not moved or disturbed. There were 22 such pairs of periods. The mean number of passages of *Reithrodontomys* per recorder-night during the full-moon periods was 2.05 and on moonless nights 3.17. The differences between the average number of passages during each full moon and each moonless period were analyzed by the Wilcoxon signed rank test and found to be not quite significant at the 10 per cent level.

Since it is widely believed that nocturnal rodents are less active on moonlit nights, since the activity difference of *Reithrodontomys* was in the direction expected (reduced activity on moonlit nights), and since the difference in activity approached statistical significance, a further attempt was made to determine if there was a real difference in *Reithrodontomys* activity associated with phase of the moon. One weakness of the preceding analysis is that the comparison, or control, periods (moonless nights) were separated from the full-moon nights by two weeks during which non-lunar events may have altered the traffic density. By using nights of half moon, during which the moon sets near midnight or rises near midnight, it is possible to have a moonlit period and a control period in the same night. This method has the disadvantage that it compares activity at times of no moon with activity at times when the moon is half full instead of full. As before, no allowance has been made for cloudy periods. For the three nights of each month when the moon set nearest to midnight, the time from one hour after sunset to one-half hour before moonset was considered to be a "moonlit PM," and the time between one-half hour after moonset and one hour before sunrise was considered to be a "dark AM." Similarly, for the three nights of each month when the moon rose closest to midnight, the time between one hour after sunset and one-half hour before moonrise was considered to be a "dark PM," and the time between one-half hour after moonrise and one hour before sunrise was considered to be a "moonlit AM." The over-all ratio of passages during these PM periods to those during the AM periods was 121 : 86. On nights when moonlit PM periods were followed by dark AM periods, the ratio was 57 : 25 (disproportionately large amount of traffic during the moonlit PM part of the night), and on nights when dark PM periods were followed by moonlit AM periods the ratio was 64 : 61 (disproportionately large amount of traffic during the moonlit AM). Plotted on binomial probability paper these ratios show a statistically significant tendency for the mice to have been especially active during the moonlit halves of these nights.

A third analysis was made in which the number of passages per night was plotted against phase of the moon at one-day intervals from full moon to

dark-of-the-moon and then back to full moon. This graph showed no progressive change in frequency of passage during the lunar cycle, only the increase during the nights of no moon (documented above).

Summarizing the conclusions from the above three analyses, there seemed to be an increase in the total amount of activity on moonless nights compared with full-moon nights, but the difference was not demonstrably significant with existing data. On nights when the moon was half full (moon setting or rising near midnight), the total amount of traffic was average, but there was a distinct tendency for passages to occur during the moonlit half of the night instead of during the moonless half. It must be concluded that moonlight of half maximum intensity not only failed to supress activity of the harvest mice but probably encouraged it.

Effect of trapping on activity.—In order to mark the individual animals that passed the recorders, small, metal Sherman box traps baited with rolled oats were set on numerous occasions near the recorders. Usually 10 to 20 traps were set before dusk within a few yards of the recorders; they were checked several times before being closed or removed between 10 PM and midnight. Mice were usually marked and released as soon as they were found in the traps, so they were sometimes caught several times in a single evening. On other occasions the mice were removed from the traps and held in cages until the end of the trapping later in the evening.

Inspection of graphs of the activity of *Reithrodontomys* shows that during some trapping periods mice continued to pass the recorders at frequent intervals and that during other trapping periods almost all traffic ceased until after trapping was stopped. Most noteworthy, however, is the fact that the total number of passages on nights when traps were operated was much greater than on nights when no traps were set. In order to test the significance of this, the number of passages of *Reithrodontomys* during the entire night was counted on each of the 29 nights when traps were set near the recorders during the first half of the night. Since traps were frequently set near two operating recorders, there was a total of 38 counts of activity on nights of trapping. These counts were then compared with the average number of passages on the two preceding and the two succeeding nights. Traffic on trapping nights exceeded that on nights without trapping on 28 nights, was less on only 5 nights, and on 5 occasions there was traffic on neither the trapping night nor on any of the four nearby nights used for comparison. The mean number of passages of *Reithrodontomys* on nights of trapping was 6.5 and on the comparison nights 3.0. This highly significant difference demonstrates that trapping stimulated the population to such an extent that the recorded activity was more than doubled, and this increase occurred in spite of the fact that some of the mice were confined to traps for part of the night.

For *Microtus* recorded at the same time and under the same circumstances, the difference in activity was not nearly so great. Activity was greater on 18 and less on 12 trapping nights. The mean number of passages on trapping nights was 6.4 and on nights of no trapping 5.5.

Effect of Microtus on activity.—It has been reported that passages of *Reithrodontomys* were frequently intermixed with those of *Microtus* (Pearson, 1959). However, there is no clear evidence that members of one species were either seeking or avoiding members of the other species. Summarization of the records from all nights (6 PM to 6 AM) shows that on 174 recorder-nights only *Reithrodontomys* used the runways, on 198 recorder-nights only *Microtus*, on 256 both species, and on 150 neither species used the runways that were being recorded. Cole's coefficient of interspecific association (Cole, 1949) and its standard error computed from these figures is + .030 ± .038. The coefficient is not significantly different from zero, which means that there was no tendency for one of the two species either to use or to avoid a runway on nights when it was used by the other species.

Number of mice per runway, and composition of the traffic.—Estimation of the number of individual *Reithrodontomys* using a runway depends upon ability

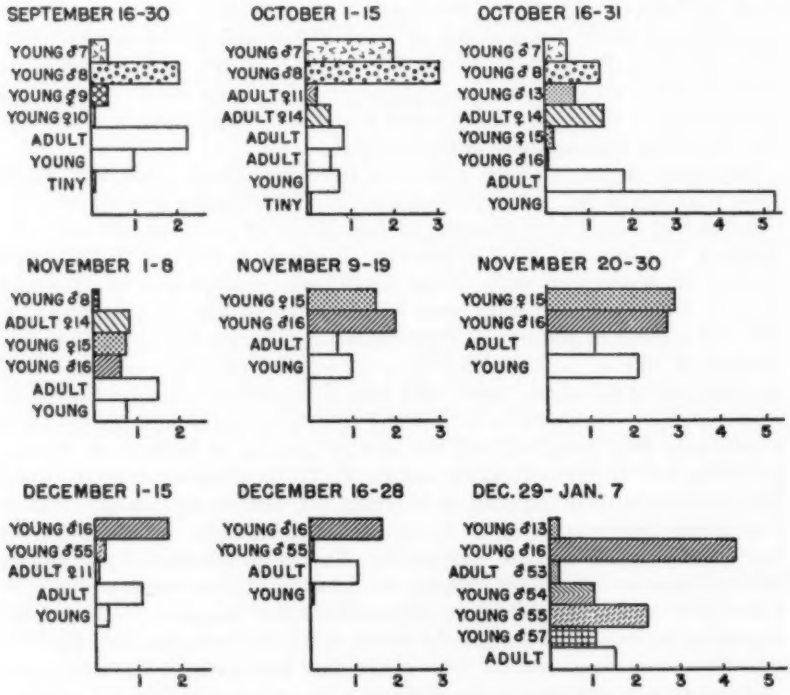


FIG. 2.—Composition and frequency of the traffic in a single runway during successive periods from 16 September to 7 January. Horizontal axis in each graph is the average number of passages per night during each time period. Columns marked only "adult," "young," or "tiny" represent passages by individuals that had not been marked but whose age was estimated from the photographs.

to recognize most of the individuals photographed in that runway. During each of 31 recorded periods lasting one to two weeks, more than half of the *Reithrodontomys* traffic was provided by harvest mice that had been live-trapped and distinctively marked. I have estimated from body size and condition of the pelage how many unmarked individuals also used the runway during each period and, to complete the estimate of the total number of individuals using the runway, have added this estimate to the number of marked mice. During some of the one- to two-week periods all of the traffic was by marked individuals. For examples of some of the estimates of the number of mice using a runway, see Fig. 2. The average of 31 such estimates is 4.4 mice, with extremes of 1 and 9. These are minimum estimates because two or more unmarked mice of the same size and appearance would have been counted as only one. I think it unlikely that the true average was more than 5, however, or the maximum more than 12.

Possibly it is more meaningful to know how many individuals used a runway in a single night. These estimates vary from 0 to 7. Nights with four individuals using the same runway were common; in fact, four different individuals sometimes passed a recorder within 45 minutes.

A history of the traffic in one runway from 16 September to 7 January is summarized in Fig. 2 to serve as an example of the changes that occur in the sex and age composition of the population using a runway over a period of time. During this time of year the last litter of young appears and reproduction ceases until the next March. The total amount of traffic by harvest mice during the period illustrated was considerably above average. The traffic by meadow mice, which exceeded that by harvest mice during September, October and November, is not shown. The number of mice using the runway varied from eight or more during October to possibly as few as four during parts of November and December (Fig. 2). The individuals in the runway were replaced completely, or almost completely, between September and January, and there were distinct changes in the sex ratio. Certain individuals, such as No. 11, disappeared from this record when changing their home ranges. No. 15 disappeared abruptly on 26 November through death or through a change of range. No. 13 seems to have disappeared late in October and returned again during the last period shown in Fig. 2. However, when he was retrapped on 28 December his markings had disappeared, so he probably was present during some of the preceding periods, but his passages would have been counted with those of unmarked individuals. No. 16, one of the most active mice in the runway illustrated in Fig. 2, shifted his home range in January but then returned in February and remained active in a runway a few feet away until June.

Time of night of activity in the runways.—Figure 3 illustrates the relation between sunset and the activity of harvest mice early in the evening, and the relation between sunrise and the disappearance of harvest mice from the runways. It may be seen that throughout most of the year harvest mice appeared about half an hour after sunset and disappeared about half an hour before

sunrise. So consistent was this pattern that it seems probable that light intensity plays a dominant role in regulating the activity of *Reithrodontomys*. The unusually early passages late in March and in April were made by three males and a female living in an underground nest box. The recorder was operating at the entrance to the box and thus registered the mice as soon as they emerged in the evening. The study area was surrounded by hills so that the actual appearance of the sun was considerably later than the official sunrise used in Fig. 3, and in the autumn and winter months the sun disappeared before the time of official sunset.

Figures 3 and 4 show that almost all activity, regardless of whether it was at a season when nights were long or short, occurred between sunset and sunrise. In some months, such as November and December, activity was rather uniform throughout the night, whereas in February and March activity was greatest during the first hour after sunset, and then diminished. There was a slight tendency, especially from November to May, toward three peaks of activity: sunset, midnight, and sunrise. During the summer, traffic began gradually after sunset whereas at other times of year it began with a burst of activity. This feature shows more clearly in Fig. 5 in which 15-minute time intervals have been used and in which time has been measured from sunset instead of from noon. A similar graph was made measuring time from sunrise and showed more clearly than Figure 5 an abrupt cessation of activity shortly before sunrise.

Examination of Fig. 5 reveals no clear tendency toward a short rhythm of

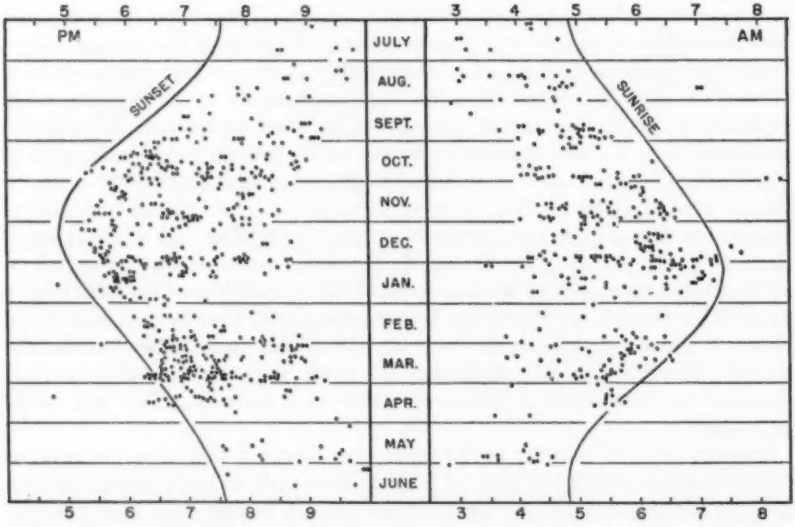


FIG. 3.—Relationship of the time of early evening and early morning activity of harvest mice with the time of sunset and sunrise.

TABLE 1.—*Time of appearance of three individual harvest mice living in a nest box*

DATE	♂53	♂55	♀45
20 March	6:33 PM	7:01 PM	7:06 PM
21 March	6:43	7:01	7:23
22 March	6:23	6:35	7:36
23 March	6:19	6:20	7:07
24 March	6:14	6:31	6:51

activity, as has been shown for several species of mice in captivity. Peaks of activity occurred ¾, 2, 3, 5 and 6½ hours after sunset, but they are not distinct enough to support any conclusions about a periodicity of activity.

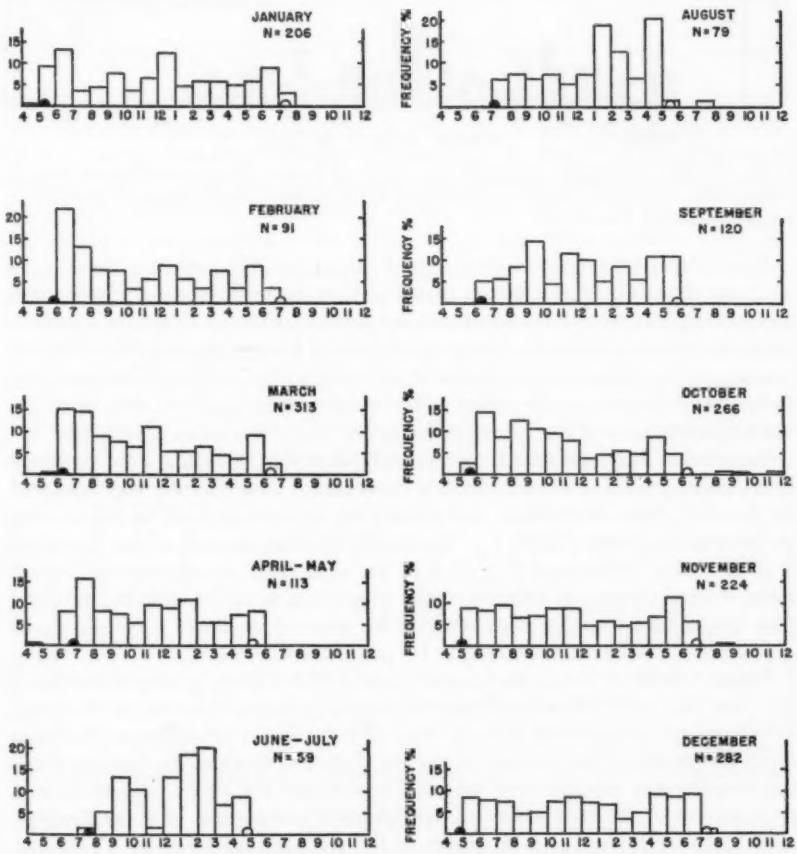


FIG. 4.—Time of activity of harvest mice throughout the year.

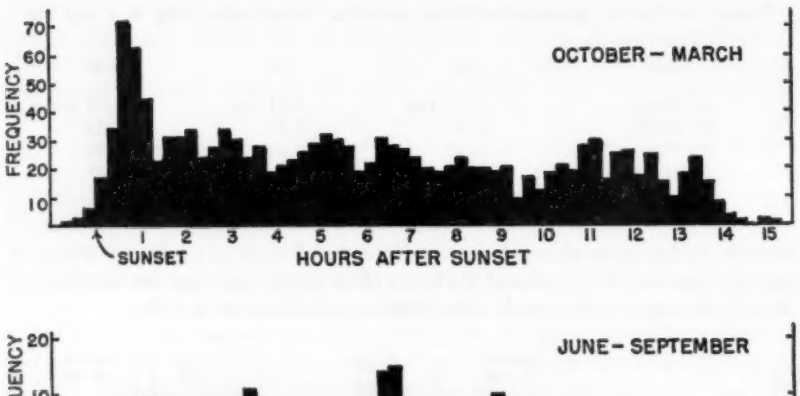


FIG. 5.—Time of activity, measured from sunset, of harvest mice at two different seasons. Vertical scale of summer sample is double that in the October–March sample to compensate for smaller size of the sample.

Time of activity of males and females.—When monthly activity patterns such as those shown in Fig. 4 are analyzed separately for activity by males and females, no obvious difference in activity pattern of the two sexes is apparent. However, by using 5-minute time intervals and by tallying only the first appearance of each individual each evening, it is possible to see a slight tendency for males to become active earlier in the evening than females. Note in Fig. 6 the preponderance of first passages by males until 20 minutes after sunset.

Included in Fig. 6 are data from a recorder that was operating at the entrance to an underground nest box. On five consecutive days the box was occupied by the same three individuals, and these three always emerged in the evening in the same sequence (Table 1). The female was last on each of the five days.

If an earlier emergence is typical of males in most populations of harvest mice, it would cause an increase in the proportion of males captured in those trap lines where the mice must compete for some of the traps. It would probably affect also the sex ratio caught by predators such as owls.

Range.—Brant (1953), using a moving grid of live traps, presented evidence that the range of *Reithrodontomys* is considerably larger than that of *Microtus*. Simultaneous operation of two photographic recorders at different distances apart has provided information about the distances traveled by harvest mice, the frequency of excursions of various lengths, and the elapsed time between appearances at the two recorders, and permits comparison of these findings with those for *Microtus*. A summary of the recorded interchanges (Table 2) reveals that there was very little traffic between recorders when they were

TABLE 2.—*Frequency of interchange of mice between two recorders different distances apart; listed in order of decreasing distance between recorders*

DATE	DISTANCE BETWEEN RECORDERS, FEET	NUMBER OF MARKED MICE	NUMBER OF PASSAGES BY MARKED MICE	NUMBER OF MARKED MICE INTERCHANGING	NUMBER OF INTERCHANGED PASSAGES*
1–30 Nov.	225	7	123	0	0
1–31 Dec	225	2	51	0	0
1–31 Jan.	225	7	178	1	1
1–15 Feb.	225	6	22	1	1
11–21 Aug.	66	2	2	0	0
22 Aug.–10 Sept.	49	1	6	0	0
11 May–19 June	46	2	25	0	0
16 Feb.–20 March	31	5	163	5	23
26 March–24 April	12	4	32	4	13
20–26 March	6	4	91	3	32

* Number of times that interchanging mice were recorded at the location that they visited least frequently.

more than 45 feet apart (only 2 of 407 passages). The habitat between the recorders was excellent for *Reithrodontomys*. At 31 feet and less the amount of interchange was much greater. Comparison of Table 2 with Table 4 in Pearson (1960) shows that the harvest mice traveled between the recorders much more frequently, proportional to the total number of passages, than did meadow mice studied at the same time in the same manner. With the exception of a single individual, the harvest mice did not appear to move greater distances than the meadow mice, but they covered the short distances between the recorders much more frequently. I suspect that the greater apparent range of *Reithrodontomys* revealed by trapping stems in part from relatively large and frequent changes of the center of activity of harvest mice.

One of the two trips between recorders when they were 225 feet apart was accomplished in 3 days; the other in 14 days. On 16 occasions a harvest mouse visited both recorders on the same night when they were 31 feet apart, and the briefest elapsed times between these visits were 4, 5¾, and 6 minutes.

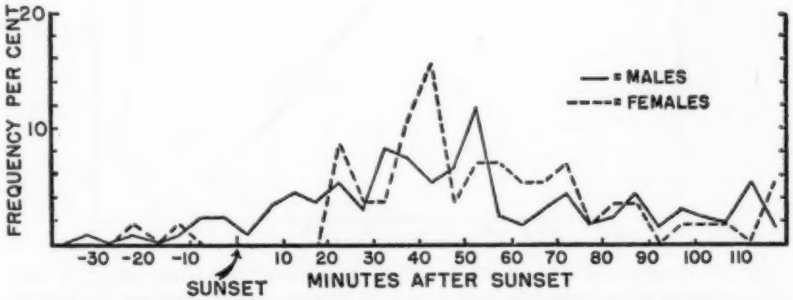


FIG. 6.—Time of the first evening passage of individual male and female harvest mice, measured from sunset.

On four occasions both recorders were visited on the same night by the same mouse when they were 12 feet apart; the quickest trip was 13 minutes. While

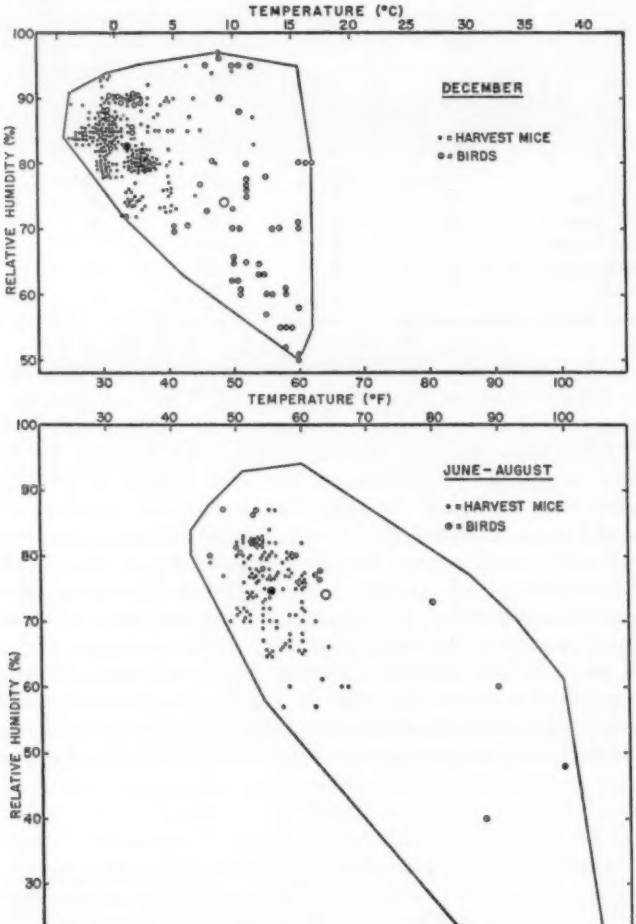


FIG. 7.—Temperatures and relative humidities encountered by harvest mice and birds in the runways during December and from June through August. Polygons enclose the total range of temperatures and humidities available during each of the two periods. The larger symbols represent the averages for harvest mice and for birds.

the recorders were 6 feet apart, 24 interchanges were made within single nights; in 8 of these the elapsed time was less than 2 minutes. The quickest was 17 seconds.

Although a harvest mouse is capable of running 6 feet in only one or two seconds, and 30 feet perhaps in only 5 or 10 seconds, it is clear that they did not often move at such speeds. One must think of this population of harvest mice as moving between recording stations more frequently than the meadow mice but, like the meadow mice, traveling at a slow rate.

Microclimate.—By graphing the temperature and the humidity recorded at the time of each passage of a harvest mouse, one can compare the conditions actually encountered by mice in the runways with the range of temperatures and humidities available in the runway. This has been done in Fig. 7, which shows, for example, that the mean temperature encountered by *Reithrodontomys* in December was 34° and in the summer 55°F. By being nocturnal the harvest mice have missed the warmer and drier conditions that existed in the runways during many of the daytime periods. Comparison of the temperatures and humidities encountered by harvest mice with those encountered by birds (mostly sparrows of several species) shows how different the microclimates of these two kinds of small vertebrates feeding on similar food in the same microhabitat can be (Fig. 7). In December, for example, the mean temperature encountered by the highly nocturnal harvest mice in the runways was on the average 15°F. lower than that encountered by the strictly diurnal birds feeding in the same runways, and the relative humidity at the times of mouse passages was, on the average, 9 percentage points higher.

Number of passages per individual per night.—Figure 1 showed a marked change in the total number of passages of harvest mice at different seasons. Some of the seasonal change in amount of activity was probably due to changes in the number of harvest mice using the runways at different seasons. In Fig. 8 this variable has been eliminated by using only passages of marked mice, thereby making it possible to obtain a figure for the number of passages

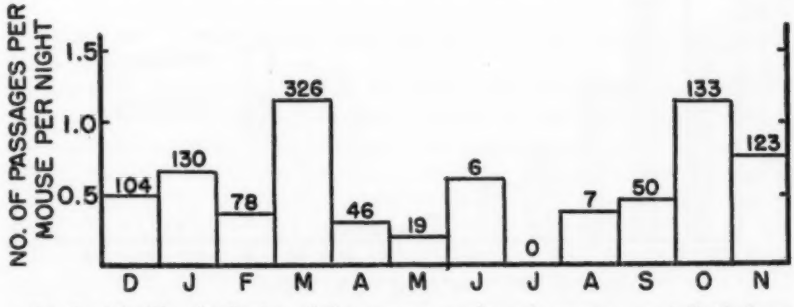


FIG. 8.—Monthly distribution of the average number of passages per individual per runway per available day. Numbers above each column show the number of passages used for each average.

per available individual per day. For these calculations I have estimated for each month the number of days that each marked individual was alive and presumably living near a functioning recorder, hence available for recording. It may be seen that the number of passages per individual per runway per available day reached a maximum of 1.15 in both March and October and was considerably less in the spring and in the summer. Males and females both showed peaks of activity in March and in the autumn, with lower activity during the summer.

During the study, 732 passages by marked males and 290 by marked females were recorded, but this does not mean that males individually were much more active than females, for there were 17 marked males and only 10 marked females, and there were also more days of recording during which passages by males could have been registered. Calculations were made of the number of days that each marked male was known to be alive and living in the region of a functioning recorder; the sum of all these was 1,006 available recorder days. For females the corresponding figure was 459 available recorder days. Dividing these into the total number of passages made by marked individuals of each sex gives an average of 0.73 passages per male per runway per day and 0.63 per female per runway per day. The difference is not statistically significant.

The calculations in the preceding two paragraphs include many series of days and even weeks when some of the marked individuals were alive but were not recorded; presumably they were active in other runways. Restricting the calculations to records of 11 marked males and 5 marked females during periods when each of the individuals was passing with considerable regularity, I have prepared a frequency distribution of the number of passages each individual made each night (Fig. 9). The most frequent number of passages per individual (mode) was 1, the mean was 1.8, and females, on the average, were as active as males. The greatest number of passages per night by any individual was 13, provided by a male about 2½ months old on 11 January.

FIG. 9.—Frequency distribution of the number of passages per mouse per night provided by 11 males and 5 females during periods when each individual was passing with considerable regularity.

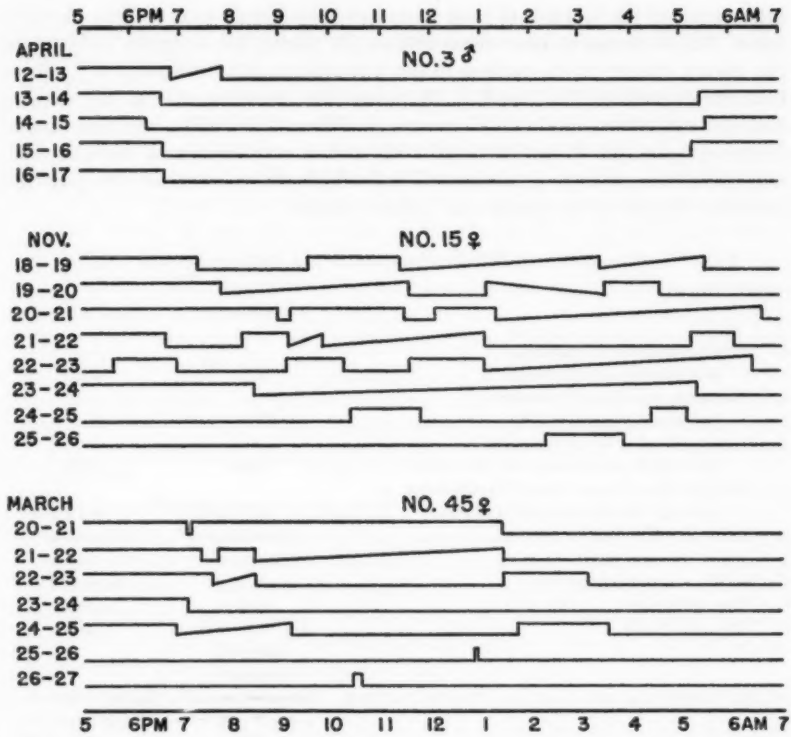


FIG. 10.—Excerpts from the records of three individual mice showing the time and direction of each passage. Ascending vertical lines represent passages toward the left and descending vertical lines passages toward the right. Slanting lines are used when two successive passages were in the same direction.

The other two highest records were also provided by young, non-breeding males in winter.

Frequently, meadow mice using the same runways as these harvest mice made long series of records in which individuals alternately passed toward the right and toward the left. These were clearly excursions from burrows out into runways, and it was possible to count the number of excursions made along a runway by each mouse in a day (Pearson, 1960). No harvest mice provided a consistent series of out-and-back records. Individual activity records such as those shown in Fig. 10 were prepared for each of the more active individuals over long periods of time, but no clear pattern of excursions could be detected, probably because the harvest mice did not limit as much of their activity to the runways as did the meadow mice and consequently one or both legs of many round trips were not recorded. It is also probable that harvest

mice changed the location of their nests more frequently than did the meadow mice. No. 45 seems to have done this on 25 March, for example, judging by the abrupt change in the pattern of her passages at this time (Fig. 10). Some individuals, such as No. 3 in Fig. 10, passed the recorder early in the evening and did not return again until morning. Others (No. 15) sometimes made numerous passages during the night but not in any consistent fashion. The only behavior common to almost all individuals was a tendency to pass the recorders shortly after sunset and before sunrise.

TABLE 3.—*Comparison of Microtus californicus and Reithrodontomys megalotis*

	Microtus	*Reithrodontomys*
a. Average number of passages per runway per 24 hours	7.8	2.25
b. Maximum number of passages per runway per 24 hours	67	27
c. Average number of passages per individual per runway per 24 hours	1.60	0.70
d. Number of mice per runway* (minimum estimates of average and extremes)	4.5 (2–12)	4.4 (1–9)
e. Traffic at full moon	decreased	decreased?
f. Traffic on rainy days	increased	no change
g. Traffic on trapping nights	increased?	increased
h. More active sex	male	neither
i. Time of activity	day and night (except in summer)	night
j. Movements	frequent use of a small part of a small home range	lighter usage of a larger part of a small home range

* The estimates on line *d* were derived from numerous short sampling periods, and may not be the average for the entire study. Partly for this reason, *c* times *d* does not equal *a*.

DISCUSSION

Although 27 or more species of vertebrates used the runways at which the recorders were operating, 92 per cent of the total traffic was provided by meadow mice and harvest mice. Harvest mice apparently depended upon meadow mice to make the runways and keep them open, but they did not favor or avoid runways being used by *Microtus*. Actual encounters between individuals of the two species were reduced by differences in their schedules of activity. Harvest mice were strongly nocturnal; meadow mice were active at all hours during the rainy season but during the dry season were active primarily shortly after sunrise. The time of activity of *Microtus* in summer was believed to be dictated by a need for the dew available early in the morning (Pearson, 1960). Harvest mice also need free water, but daybreak apparently drives them to their nests at that hour in the summer when dew is most

plentiful. The different activity patterns of the two species also subject them to different temperatures and vapor pressures, to different associates in the runways, and to different predators.

In Table 3 a comparison is made of some of the habits of these two species that shared the runways so intimately. The *Microtus* information is from Pearson (1960). Although the number of individuals using a runway during any one period was roughly equal between the two species, comparison of the number of passages per individual per 24 hours shows that each individual *Microtus* tended to pass the recorder more frequently than did each *Reithrodontomys*. This fact, coupled with the fact that harvest mice interchanged more frequently than *Microtus* between two recorders operating simultaneously many feet apart, suggests that meadow mice make relatively great use of certain runways close to their nest whereas harvest mice probably use more different runways and leave the runway systems more frequently, thereby reducing the frequency of passage in any one runway. This habit may make them less vulnerable than meadow mice to predation by still-hunting predators, such as cats, but increases their vulnerability to roving predators such as certain kinds of owls.

Microtus californicus, a species that does not hesitate to come out in the daytime, avoids full moon as distinctly as does nocturnal *Reithrodontomys*. Although it is not obvious what physiological machinery controls this behavior in *Microtus*, the avoidance of full moon by *Microtus* is made with little sacrifice because a meadow mouse can postpone until daytime whatever above-ground activity it wished to carry out during a moonlit night, whereas a harvest mouse would have to postpone it until the next night.

Meadow mice eat leaves and stems of weeds and grasses as well as seeds, flowers and fruits. They were photographed frequently carrying cut pieces of leaves and stems. Only once was a harvest mouse noted carrying vegetation. Because of the large size and different food habits of *Microtus*, a dense population of meadow mice has a more obvious impact on the environment. *Microtus* cuts down and consumes much of its cover, thereby exposing itself as well as its *Reithrodontomys* associates to increased predation.

SUMMARY

Harvest mice were studied through the use of automatic photographic recorders placed along runways made by meadow mice. Harvest mice averaged 2.25 passages per runway per 24 hours. During October, the month of greatest activity, they averaged 8 passages per night. The number of passages per night was the same on rainy and rainless nights. Activity was greater on moonless than on full-moon nights, but the difference was not statistically significant. On nights when the moon set or rose near midnight (moon half full), there was a distinct tendency for passages to occur during the moonlit half of the night. Activity was much greater on nights when mark-and-release trapping had been carried out during the early part of the evening. There was no tendency for *Reithrodontomys* to use or to avoid a runway on nights when it was used by *Microtus*.

Minimum estimates of the number of individual harvest mice using a runway during one- to two-week periods varied from 1 to 9 with a mean of 4.4. The greatest number of individuals that passed in any one night was 7.

Harvest mice appear in the runways about half an hour after sunset and disappear about half an hour before sunrise. There is a slight tendency for males to appear earlier in the evening than females. Both sexes show a peak of activity early in the evening, except during the summer.

There was little traffic between recorders more than 45 feet apart; at closer distances interchanges were more frequent but rarely were accomplished rapidly.

The mean temperature encountered by harvest mice in the runways in December was 34°F. and in the summer 55°.

The number of passages that each individual made per runway per night reached an average of 1.15 in both March and October and was considerably less in the summer. Females made as many passages per individual per night as did males. One individual made as many as 13 passages in one night.

LITERATURE CITED

BRANT, D. H. 1953. Small mammal populations near Berkeley, California: *Reithrodontomys, Peromyscus, Microtus*. Ph.D. Thesis, Univ. Calif., Berkeley.

COLE, LAM. C. 1949. The measurement of interspecific association. Ecology, 30: 411–424.

PEARSON, O. P. 1959. A traffic survey of *Microtus–Reithrodontomys* runways. Jour. Mamm., 40: 169–180.

———. 1960. Habits of Microtus californicus revealed by automatic photographic recorders. Ecological Monogr., in press.

Museum of Vertebrate Zoology, Univ. of California, Berkeley. Received 11 September 1958.

THE REPRODUCTIVE ORGANS OF THE COLLARED LEMMING UNDER DIVERSE TEMPERATURE AND LIGHT CONDITIONS

BY W. B. QUAY

A colony of 110 collared lemmings, *Dicrostonyx torquatus*, was maintained and studied over a period of 2½ years. These animals include 17 litters produced in captivity from parental stock obtained within ½ mile of the town of Churchill, Manitoba, Canada in August 1953 and July 1954. Observations on the requirements, behavior, reproduction, growth and diseases of the animals have been presented previously (Quay and Quay, 1956). The use of the name *torquatus* follows the nomenclature proposed by Rausch (1953). Of paramount interest are the physiological and microanatomical characteristics of this arctic mammal which respond to modifications of temperature and light and which may have adaptive or biological significance. The present report summarizes the effects noted in the reproductive organs of lemmings maintained in diverse temperature and day-length conditions.

I am grateful to the Horace H. Rackham School of Graduate Studies, University of Michigan, for support in 1954 and to the R. C. Mission at Churchill for generous assistance.

MATERIALS AND METHODS

Twenty-five captives and eight lemmings preserved in the field were used in this study. Their ages ranged from 3 months to over one year. The main colony was kept in an artificially and constantly lighted room at 70–80°F. (usual temperature 75°F., = "warm-light"). Groups of animals were periodically transferred from this room to either a dark basement room for 4 months at 74°F. (= "warm-dark") or to a thermostatically controlled deep-freeze cabinet with a transparent lid and forced-air circulation. Animals in the deep freeze were never given sufficient bedding for them to completely cover themselves and were subjected to a gradually decreasing temperature during 10 to 14 days and continuous cold for up to 2½ months. The final temperature varied spatially within the cabinet from 15 to 22°F. Artificial lighting over the cabinet was either continuous (= "cold-light") or was supplied in daily periods decreasing in length until continuous darkness was attained (= "cold-dark"). During one four-day period in the summer several of the lemmings in the main colony were subjected to temperatures of 89–92°F. (= "hot") due to breakdown of the air-conditioning equipment. Most of the animals used in the experiments were ultimately anesthetized with ether and perfused and fixed in Bouin's fluid. Just before perfusion, blood samples were taken from one of the jugular veins for counts. These were used primarily as checks on the health of the animals. In nearly all individuals, erythrocytes numbered 10 to 15 million per cubic millimeter of blood, and the highest values were possessed by healthy lemmings in the cold. Leucocytes varied from 1,000 to 20,000 per cubic millimeter and tended to be more numerous in animals maintained at 74°F. or above. Samples of tissues for microscopic study were washed, dehydrated, embedded in paraffin, sectioned at 7 microns and stained with acid alum hematoxylin and eosin.

RESULTS

In some of the lemmings' reproductive organs, the microanatomy is sufficiently distinctive to necessitate description of the normal structure before the changes can be presented. Therefore, the results are divided into sections dealing separately with the descriptive and the experimental data.

No distinct correlations could be found between reproductive microanatomy and modification of the daily period of light. All of the changes found appear to be most readily associated with temperature conditions.

Histology of Female Organs

Ovarian bursa.—The ovaries of the collared lemming, like those of the laboratory rat and mouse (*Rattus* and *Mus*), are each enclosed within a periovarial sac, bursa ovarii, or ovarian bursa. The structure of this sac even in the common laboratory rodents has until recently been poorly known. This has been particularly true for the duct that normally connects the periovarial space and the peritoneal cavity (Alden, 1942; Wimsatt and Waldo, 1945). All of

the examined lemming ovaries that are well preserved and that are represented by complete serial sections are inclosed in a periovarial sac which has a single duct leading to the peritoneal cavity (Plate I, bottom right). The anatomical

PLATE I

TOP: Ovary of lemming No. 75 (born in captivity, 13 months old; "warm-light" then 89–92°F. for 2 days). Note ovarian follicles in different stages of growth (at left) and atresia (at right), and the uterine tube (upper left).

BOTTOM LEFT: Ovary of lemming No. 52 (captured when about 1 month old; now about 4 months old; "warm-light" then "cold-light" with decreasing temperature 2 weeks and 15–20°F. 4 days; autopsy 23 October). Note lack of follicles with antra, survival of colloidal bodies from old atretic follicles, and the density of the stromal-interstitial cells.

BOTTOM RIGHT: Example of long duct between ovarian bursa to peritoneal cavity (arrows), uterine tube (upper right) and uterine horn with entrance of tube through intrauterine papilla (lower part of field); lemming No. 75.

PLATE II

TOP LEFT: Atretic ovarian follicle of lemming No. 11 (captive 6 months, "warm-dark" 4 months, 1± years old, autopsy in January) showing typical degenerative changes in the ovum and granulosa and the relatively fusiform thecal cells.

TOP RIGHT: Atretic ovarian follicles of lemming No. 57 (born in captivity; "cold-dark" 2½ months; 7½ months old; autopsy in March) showing survival and hypertrophy of granulosa and thecal cells and cords of rounded stromal-interstitial cells between follicles.

BOTTOM LEFT: Cervical epithelium of lemming No. 57 ("cold-dark," data above). Note thinness of epithelium (2–4 cells), lack of secretory activity, and densely packed small fusiform cells in the connective tissue.

BOTTOM RIGHT: Cervical epithelium of lemming No. 75 ("warm-light" then 89–92°F. for 2 days; 13 months old). Note increased thickness of epithelial layer and cellular hypertrophy and secretory activity. The connective tissue also is less dense and shows some neutrophil infiltration.

PLATE III

TOP: Typical area from testis of lemming No. 61 ("warm-light," born in captivity, 6 months old; autopsy in January).

MIDDLE: Typical area from testis of lemming No. 29 ("cold-light" with decreasing temperature 2 weeks, 15–20°F. 38 days; 9–12 months old; captive 5 months; autopsy in December).

BOTTOM: Typical area from testis of lemming No. 80 ("cold-dark" with cold 4¾ months and darkness 2 months; born in captivity; 16 months old; autopsy in December).

PLATE IV

TOP: Longitudinal section of an entire preputial gland of lemming No. 85 ("warm-light," 3-month-old ♂). The basal area is at the upper right and the distal (anterior) at the left. The black lines mark the separation of granular (distal) and nongranular (basal) types of parenchyma.

MIDDLE: Longitudinal section of a preputial gland of lemming No. 75 ("warm-light" then 89–92°F. 2 days; 13-month-old ♀). The orientation and magnification are the same as for the above gland. Some isolated islets of parenchyma beyond the left margin are not shown.

BOTTOM LEFT: Small area in high-power from preputial gland of lemming No. 29 ("cold-light," 9–12-month-old ♂) showing a lobule of "granular" parenchymal cells above and a lobular of "nongranular" cells below.

BOTTOM RIGHT: Area from preputial gland of lemming No. 71 ("warm-light;" 5½-month-old ♀), showing replacement of parenchyma by connective tissue, unilocular fat cells.

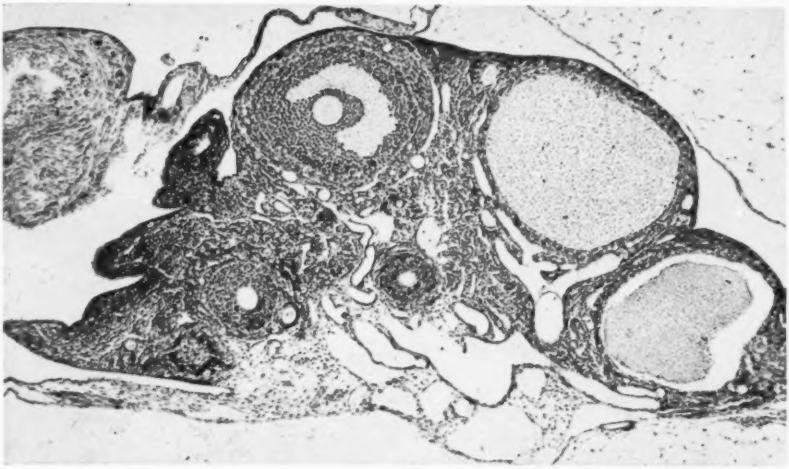


PLATE I

Legend opposite

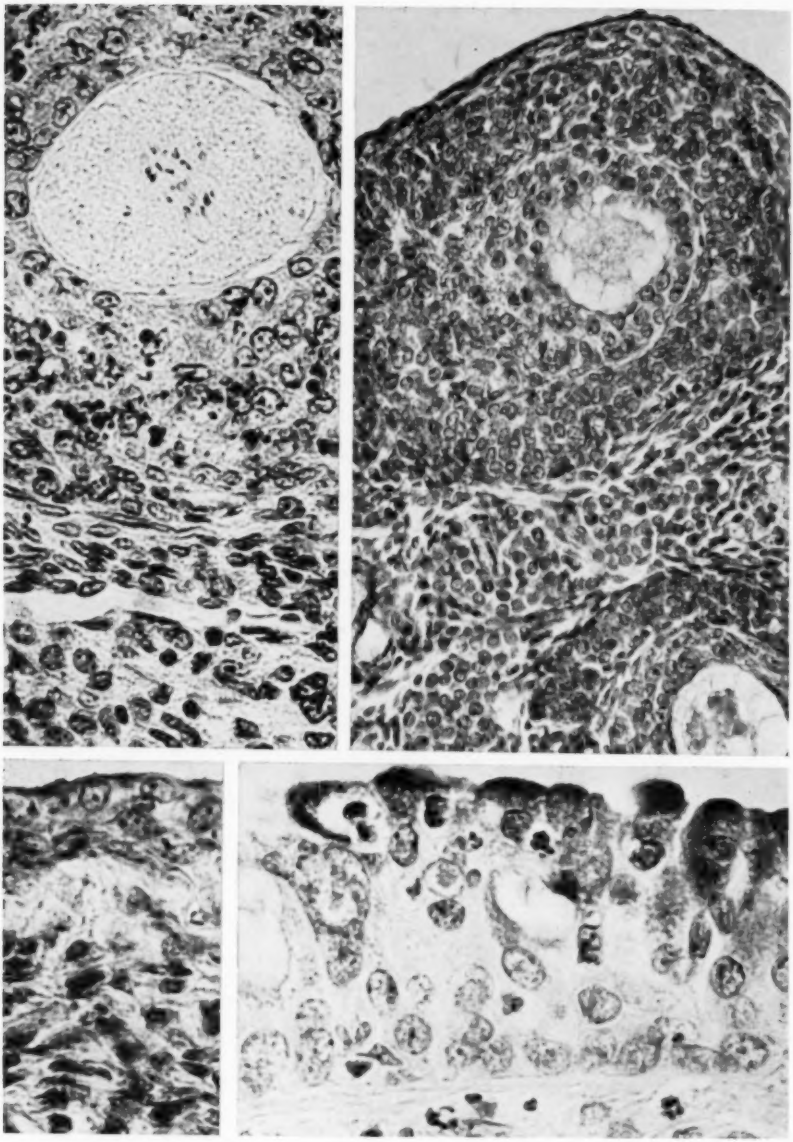


PLATE II

Legend on p. 76

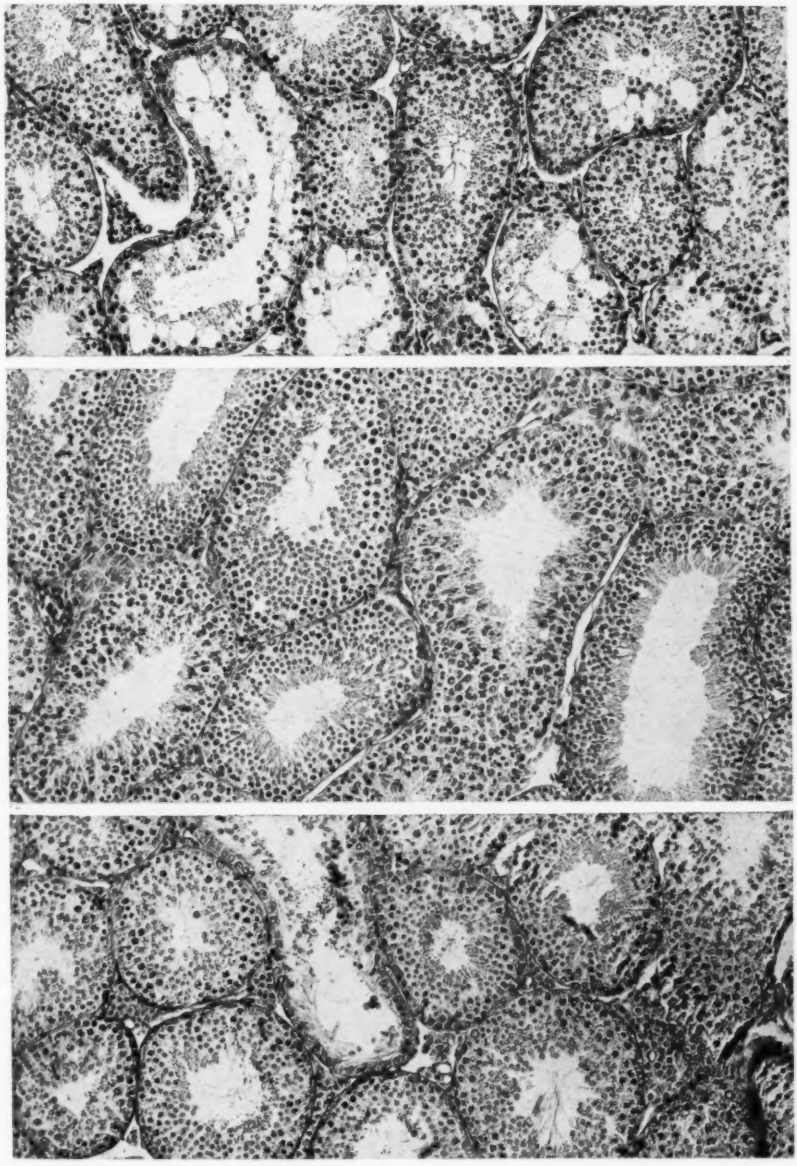


PLATE III

Legend on p. 76

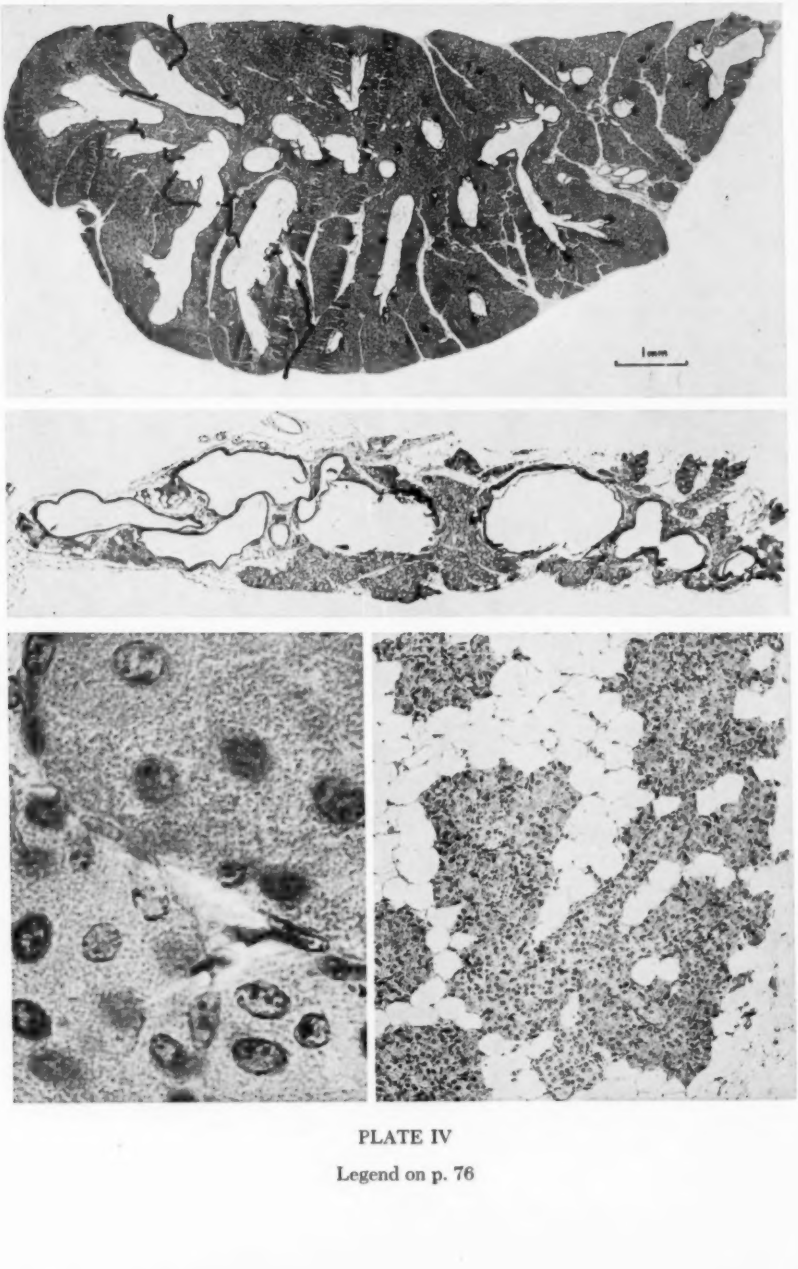


PLATE IV

Legend on p. 76

relations of this duct and its great variation in length are similar to those described in the rat and mouse by the above authors. However, two peculiarities were noted in the lemming. In all cases, the external or peritoneal opening of the duct is either surrounded by, or lies adjacent to, a tuft of papillae which extends into the peritoneal cavity. The papillae are frequently branched, are up to 170μ in length and are usually from 12 to 30μ in diameter. The mesothelial covering of the papillae is composed of more closely spaced and less flattened cells than is that of the covering of adjacent areas of the sac. The axial portion of each papilla is occupied by a delicate framework of connective tissue which contains numerous capillaries. This structure suggests that an enhanced secretion of peritoneal fluid may occur in this area adjacent to the opening of the periovarial sac. There is a need not only for the study of this structure during ovulation but also for a careful comparative study of the ovarian bursa and related structures in rodents generally.

The second peculiarity noted in the lemming bursal duct was the presence in one animal of a branched tubular "gland" opening into the middle portion of the duct. While the duct itself is lined with a simple cuboidal non-ciliated epithelium, the "gland" is lined with simple columnar, continuously ciliated epithelium, resembling that of the most distal portion of the fimbria of the oviduct.

Ovary.—The numbers of oöcytes of the three primary types in well-preserved ovaries are listed in Table 1. The primordial follicles are those that are walled by no more than a single layer of granulosa cells. The secondary follicles are those that are walled everywhere by two or more layers of granulosa cells and in which no more than a trace of an antrum may be seen. Vesicular follicles are those with developing or large antra. The number of primordial follicles in the adult lemming ovary appears to be greater than that noted in the laboratory rat by Arai (1920) and by Green, Mandl and Zuckerman (1951). However, the magnitude of this difference is impossible to determine without information on oöcyte production and fluctuation during the lemming's estrous cycle. More striking is the relatively low number of secondary and vesicular follicles in the lemming ovaries. The significance of this will be discussed later in relation to the effects of captivity and temperature. The mitotic activity in the thecal layers and in the granulosa seems in general to follow the patterns described in several laboratory rodents. Likewise the first appearances of atresia in the follicles and oöcytes seem to be the same as those described in other species (see especially, Harmon and Kirgis, 1938; Schmidt, 1942; Allen *et al.*, 1943). In atretic, nearly mature, vesicular follicles maturation divisions occur frequently in the ova as has been described previously in other mammals (Plate II, top left). In one specimen vesicular follicles range from over 400 to 600μ in mean diameter and contain ova 58 to 59μ in mean diameter. Lemmings of different ages and subjected to different environments show differences in the late atretic changes and in the ovarian interstitial-stromal complex of cells. Although these will be considered later under environmental effects, it may

TABLE 1.—*Number of oöcytes in well-preserved lemming ovaries; all ovaries lacked corpora lutea, and atretic follicles were not counted; additional explanation in text*

CONDITION; SPEC. NO.	AGE, MOS.	OVARY NO.	PRIMORDIAL FOLLICLES			2+ LAYERED FOLLICLES	VESICULAR FOLLICLES
			normal	binuclear	trinuclear		
Cold + light							
No. 52	4	1	3107	4	0	8	0
		2	3219	4	0	7	0
Cold + dark							
No. 57	7½	1	2976	3	1	13	0
Warm-dark							
No. 11	12+	1	1894	1	0	50	4
		2	1573	1	0	46	4
Hot							
No. 75	13	1	1631	3	1	17	5

be noted now that, in general, both the granulosa and the theca interna remain at least partially active in late atresia, particularly in the secondary follicles. In several ovaries enlargement and transformation of the thecae of secondary atretic follicles appear to be forming large masses of interstitial tissue. The granulosa cells that survive for the longest time are usually the outermost ones and show progressive vacuolization as well as pigment formation in many ovaries.

The lemming ovary contains cortical and medullary zones which become more distinct in the older individuals. The cells forming the stroma and the interstitial masses constitute an array of cytological variants that are difficult to clearly define without the aid of cytochemical techniques. About five classes of cells might be distinguished on the basis of nuclear structure. Those that might represent interstitial cells have larger, more oval, and more finely granular nuclei and are located in deeper areas of cortex and sometimes into the medulla. While these cells generally have more cytoplasm than the stromal cells, cytoplasmic structural characteristics are obscure in our preparations.

Epoöphoron.—The tubules comprising the epoöphoron are usually present and well developed in the lemming. The smaller tubules of this structure, presumably derivations of the embryonic mesonephric tubules, extend to a variable extent between the large duct (mesonephric) and the hilum of the ovary or the adjacent lining of the periovarial space. The large and small tubules of the epoöphoron are usually patent, and sometimes open into the periovarial space. Occasionally isolated segments are cystic.

Uterine tube.—The fimbria and uterine tube of the collared lemming resemble anatomically those of the rat (Kellogg, 1945). The uterine tube or oviduct is completely coiled and a significant segment of it as well as its fimbriated end remains within, or in the wall of, the ovarian bursa. The epithelium of the fimbria is nearly continuously ciliated in all individuals, although this is broken by the cellular extrusion characterizing anestrus and cold-treated animals.

Ciliation is patchy or irregular in the middle portion of the uterine tube and is generally absent in the lowest portion. The epithelium of the fimbria and uterine tube is simple columnar and varies from 9 to 50μ in height, increasing in height down the tube and during periods of estrus and pregnancy. The extrusion of cells into the lumen characterizes the epithelium of the fimbria and uppermost tube. The muscularis of the tube increases in thickness downward or toward the uterine horn and consists primarily of circular or closely spiraling fibers of smooth muscle. A distinct but thinner outer longitudinal layer of smooth muscle is found particularly in the lower area of the tube. A very tenuous inner longitudinal layer is found in the lowermost tube and extends into the intrauterine papilla through which the tube enters the uterine horn (Plate I, bottom right).

Uterus.—Although the horns of the uterus are fused basally in the lemming, the lumina of the two sides of the uterus and the two cervical canals remain separate as described in the bank vole (Brambell and Rowlands, 1936). The horns and body of the uteri are similar histologically. They are lined by a simple columnar, non-ciliated epithelium and contain a muscularis (myometrium) composed of three layers of smooth muscle, a middle circular and inner and outer longitudinal layers. Tubular and dilated tubular glands are restricted to the horns and body of the uterus. The cervical canals are unique in their stratified epithelial lining which is sometimes thrown into numerous folds and is actively secretory, but lacks true glands. Actively secreting cervical epithelium is stratified or pseudostratified columnar and may contain deep crypts into which secretion passes from deeper cells. Within the cytoplasm of these cells are numerous vacuoles and an intensely basophilic fibrous material, suggesting a strongly acidic mucoid secretion (Plate II, bottom right).

Effects of Temperature

Ovary.—Cold rather than heat appears to be more significant in producing ovarian changes. Three general features of ovarian histology are involved: (1) growth and maturation of follicles, (2) atretic changes, and (3) composition of the stromal and interstitial tissue. Primordial follicles containing structurally normal oöcytes seem to be equally numerous in the cold- and warm-treated ovaries, if one allows for the expected decrease in these with age. On the other hand, all of the cold-treated ovaries are distinguished from control and warm-treated ovaries by a reduction in the number of secondary follicles and absence of large vesicular follicles and corpora lutea (Plate I). Atretic changes in secondary follicles in cold-treated ovaries appear to start in the inner portions of the granulosa, but are slow to involve the outer granulosa layers (Plate II). The outer granulosa cells, and frequently most of these cells, hypertrophy and survive long after the ovum has disappeared. The theca thickens and cytologically resembles interstitial tissue. In old atretic follicles the granulosa cells are reduced to one or several thin layers of pigmented or frothy cells surrounding a cavity containing a colloidal mass and the enlarged thecal cells blend imperceptibly into the surrounding interstitial tissue. The colloidal masses, represent-

ing the central portions of old degenerated follicles, appear to remain for an extended period and accumulate most frequently in the deeper part of the cortex.

In ovaries of animals fixed on capture at Churchill or fixed after various periods in warm temperatures in captivity, the stromal and interstitial tissues appear to be loosely arranged, contain cells of greater cytoplasmic content and are permeated by more numerous and dilated small blood vessels. In ovaries of cold-treated animals, the more fibrous types of cells and dilated vessels appear to be reduced and the stromal-interstitial complex consists almost entirely of solid cords of interstitial-like cells between narrow capillaries. The cytoplasmic content of these cells appears reduced and they give the ovaries a densely cellular appearance (Plate I, bottom left).

Uterine tube.—Individual variations in the lemming uterine tube concern primarily the fimbriated end and its epithelium and appear to correspond to the estrus-anestrus changes described in other rodents. In anestrous lemmings and especially in lemmings in the cold: (1) the epithelium of the fimbria is 7–18μ high instead of 11–34, (2) mitoses are rare in the epithelium, and (3) many cells are being extruded into the lumen.

Uterus.—In the horns and body of the uteri of lemmings kept in the cold an extreme anestrous condition is found. The epithelial lining is 6–13μ thick, while in lemmings in warm and hot environments it is 12–30μ. The uterine glands are slender and many of them lack a central lumen in the cold. The smooth muscle cells of the myometrium are slender and dense in these animals.

The cervical canals take on an extreme anestrous condition in the cold. The epithelium here is reduced to only a few cells (2–6) in thickness, the most superficial cells are flattened and there is no evident secretory material (Plate II).

Histology of Male Organs

Testes.—The histology of the male gonads and epididymis in lemmings is in general similar to that in the laboratory rat (*Rattus*) and mouse (*Mus*). The seminiferous tubules are large and coiled and lead into confluent rete tubules which are drained by means of a small number of efferent ductules. A highly secretory area of the epididymis is located in the head of this tissue and there are marked fluctuations here in epithelial height and secretory activity. Most of the epithelial cells here bear stereocilia and many others appear to go through a secretory cycle in which large numbers of eosinophilic granules are produced within the cytoplasm and are later extruded into the lumen. Only small numbers of sperm are seen in this area. Storage of sperm is always observed in the tail of the epididymis and the relative number of sperm in this area does not appear to always reliably reflect the extent of spermatogenetic activity within the body of the testis.

Effects of Temperature

Testes and epididymis.—Spermatogenesis was active in nearly all the seminiferous tubules of some adult feral lemmings captured in August and of

all adult captive lemmings kept in cold and light for periods up to 38 days. Adult males maintained in warm rooms in either light or darkness usually show some degree of reduced spermatogenesis, revealed most clearly by the number of thin-walled and atrophic seminiferous tubules containing abnormal cell-types and no sperm or spermatids. In a six-month old male (No. 61, warm-light, Plate III) 43 per cent of the seminiferous tubules, viewed in cross-sections, lack sperm and an additional 32 per cent are decidedly atrophic. In a three-month old male (No. 35), however, maintained under the same conditions as the one just mentioned and autopsied during the same month, nearly all of the seminiferous tubules are large and actively spermatogenetic. While our data suggest an age difference in the reduction of spermatogenesis due to higher temperature, they are not sufficient for a thorough analysis of this probability. One 16-month-old captive (No. 80), maintained in the cold for 4¾ months and in darkness for the latter half of this period, showed reduction of spermatogenesis and some tubular atrophy (Plate III). In this animal, degenerative changes are evident in most of the tubules in the segment adjacent to the rete, but distally only about 8 per cent of the tubules show such changes. Of the remaining tubules, viewed in cross-sections, 34 per cent contain sperm and 58 per cent lack them.

The interstitial cells of the lemming testes are usually numerous and contain vacuoles as well as yellow pigment. Variations in the numbers of these cells per cluster, and in the amount and pigmentation of their cytoplasm are present but not readily segregated according to light or temperature treatments.

Epithelial height and secretory activity in the head of the epididymis appear to be greatest in the animals in the cold and in the 3-month-old animal in the lighted, warm room (No. 85).

Seminal vesicles and prostate glands.—The seminal vesicles and the closely attached coagulating glands in the lemming are grossly similar to those of the laboratory rat. Our materials on the smaller prostate glands are deficient and do not permit comparisons to be made at this time. Variations in the lemmings examined appear to be significant only in regard to the amount of secretion within the lumina of the seminal vesicles and coagulating glands. The amounts are invariably great in the animals in warm and hot rooms and were usually less in the cold-treated animals. The height of the glandular epithelial cells did not show a distinct difference between the groups.

Preputial glands.—The pair of preputial glands, since they are large in both sexes in *Dicrostonyx,* will be considered here separately from the other reproductive accessory organs. Nevertheless, they are most readily stimulated by androgens (Dorfman and Shipley, 1956) and are frequently thought of as primarily male accessory reproductive glands. Descriptions and reviews of the anatomy and histology of the rodent preputial gland have been provided by Schaffer (1940) and Montagna and Noback (1946). The preputial glands of microtine rodents have rarely been examined microscopically and, as our results show, there is a need here for more comprehensive comparative and experimental studies.

While skinning and dissecting lemmings, I have been frequently impressed by the sharp color difference between the distal and basal parts of the gland, a feature which I have never seen in the preputial glands of laboratory rats (*Rattus*). In specimens of *Dicrostonyx* preserved even for long periods in formalin solutions, the preputial glands show two sharply delimited areas. The most distinctive of these is the distal area which is much paler in color and comprises about ⅓ to ½ of the total mass of each gland. In slides stained with hematoxylin and eosin the distal and basal areas are usually sharply defined cytologically (Plate IV). The parenchymal cells of the distal area are filled with coarse, eosinophilic cytoplasmic granules and those of the basal area are paler and have only very fine granules. However, in a few specimens occasional, scattered, coarsely granulated cells occur in the basal area and in other individuals the granulation of the distal area is reduced. In both areas, the parenchymal cells take part in a holocrine secretory process typical of sebaceous-type glands generally. That is, lipid droplets, revealed as vacuoles, accumulate in the cytoplasm as the cells enlarge, degenerate and finally are sloughed into the lumen of the glands' duct. Structurally the preputial gland of *Dicrostonyx* resembles that of the rat; both are large tubo-alveolar sebaceous-type glands. But in *Dicrostonyx* vacuolated parenchymal cells are less numerous and more of the parenchymal cells appear to be active metabolically according to their nuclear morphology. The lemming gland is also extensively lobulated and the septules between lobules contain numerous capillaries. Most interesting of all probably are the physiological changes to be described subsequently. It may be noted that the age changes characteristic of the structure of the rat's preputial gland may be noted also in the lemming. With age the ducts increase in length and diameter and the secretory alveoli become more peripheral in distribution.

Microscopically visible modifications in preputial glandular activity that can be readily seen in our material pertain to the following features: (1) mitotic activity in the parenchyma, (2) relative amounts of cytoplasmic granulation and vacuolation, (3) decrease and resorption of cytoplasmic material, (4) holocrine secretory activity and the progressive changes in the parenchymal cells involved in this process. The first two of these features are difficult to evaluate without closer control of fixation, but some of the more marked characteristics here may be sufficiently significant. Parenchymal cell mitoses are found in both distal and basal areas of the preputial glands in at least some of the animals in each light and temperature regimen. Even in one of the animals (No. 75) in high temperatures, while there is extensive parenchymal resorption, parenchymal mitoses are numerous, apparently in both basal and distal areas of the glands. Relative amounts of parenchymal cytoplasmic material, granulation, and vacuolation vary more widely and are more easily appraised in the distal or granular portion of the gland. Here, cytoplasmic amounts and degree of granulation appear to be most frequently greatest in cold-light-treated and in wild males. Decrease and resorption of parenchymal

cytoplasm occurred in many of the wild females, and in some cold-dark, warm-dark, warm-light, and hot animals of both sexes, especially in the distal region. Extreme resorption and degeneration of the distal part of the gland occurred in all of the animals subjected to high temperatures for 1 to 2 days (Plate IV). Besides the cytoplasmic depletion, binucleate and giant nucleated parenchymal cells, increased capillary and leucocyte activity are observed in the glands undergoing severe resorption. Following this, slender cords and clusters of non-granular parenchymal cells may remain while adipose connective tissue replaces the gland tissue in areas of complete degeneration. In female lemmings especially, there are indications of chronic or periodic resorption and renewal of distal or granular preputial tissue, both in captive and feral individuals. It may be concluded from our material that perhaps periodically in females and under conditions of stress (heat, sickness, etc.) in both sexes the distal preputial gland area degranulates and in severe circumstances may involute. The basal or non-granular area of the gland is rarely as markedly involved in this process.

There are two cytological types of holocrine secretion in the lemming preputial glands. The first of these, found generally in both basal and distal areas, is typical of most sebaceous-type glands. In this case, cytoplasmic vacuoles increase progressively first in number and then by fusion in size, as the nucleus becomes pyknotic and degenerates. In the second type, the cells hypertrophy, become basophilic and flocculent and the nucleus usually remains vesicular and rather large even when the secretion mass is sloughed into the lumen of a duct. The second type of holocrine secretion was found only in feral females and in severely stressed captives showing the first stages of cytoplasmic degranulation and resorption. While the hypertrophic and basophilic type of secretion was generally found in the distal part of the gland it was not possible to claim its restriction to this area, since the boundaries between this area and the basal area become obscure as cytoplasmic degranulation ensues and before resorption is marked. Both types of holocrine secretory activity occurred in feral females and severely stressed animals, frequently in adjacent lobules. The first type of holocrine secretory process was very active in these animals, but was also very active generally in most warm and hot animals and in feral males.

DISCUSSION

It may be inferred from our results that as far as influence of temperature is concerned, the testis is adversely affected by high temperatures and the ovary by low. The relevancy of our experimental temperature conditions to those operating on wild populations is obscure on several points. Although the temperature of the lemming's microclimate is poorly known, it may be surmised that a retreat to temperatures near 32°F. is usually possible at all seasons. Our animals maintained in continuous warmth (75°F.) and light were fertile, but tended to be irritable and produced fewer young per litter than do feral populations (Quay and Quay, 1956). The decreased spermatogenesis of the

adult males maintained for up to 6 months in these conditions probably contributed to the lack of success with many of the attempted breedings. Decrease in male fertility with atrophic changes in the testes during summer or warmer temperatures has been frequently noted in mammals to be due to lowered thyroid activity (Maqsood, 1952). The reduction in litter size in the captive lemmings may be due largely, however, to reduced gonadotrophic activity in the female under the somewhat stressful and abnormal conditions, but our evidence for this is weak as yet. The sensitivity of the mammalian gonads to certain dietary factors is well known and it is possible that the thresholds for temperature injuries may be significantly modified by diet. It may be noted that our animals were supplied weekly with slices of apples, carrots and willow (*Salix*) twigs and leaves throughout the year.

The lemmings in the deep-freeze (15–22°F.) were housed in small individual cages in the initial experiments, but later, pairs were allowed to roam throughout the inside floor area of the freezing cabinet. These individual pairs nested together and appeared more congenial and less irritable than those in the main colony (75°F.). Nevertheless, young were never produced by the females in the cold and this appears to be due primarily to failure in ovarian follicle maturation and growth. Spermatogenesis continues to be active in the cold.

The importance of the rodent preputial glands for reproductive activity or for eliciting behavioral responses through scent has been suggested but is not well documented (Stanley and Powell, 1941). In microtine rodents, including lemmings, these glands are unusually large and merit more detailed study. The differences noted in the secretory activity of preputial glands in feral and captive lemmings suggest a complexity of composition and function beyond that observed in the laboratory rat. The striking glandular breakdown in females in summer and in stressed captive animals presents the interesting possibility that the scent modality in reproductive behavior or territorial marking may be greatly modified. How significant this may be in normal and crowded populations for reproductive and social behavior remains unknown.

SUMMARY

The reproductive organs of 25 collared lemmings (*Dicrostonyx torquatus*) were studied microscopically after: (1) continuous light and 75° (70–80°F.), 3–6 months; (2) continuous dark and 74°F., 4 months; (3) continuous light and cold (15–22°F.) for up to 36 days; (4) continuous darkness and cold (15–22°F.) for up to 2½ months; (5) continuous light and heat (89–92°F.) for 1–4 days following (1). Adult males in warm or hot environments show reduced spermatogenesis and females in the cold present an anestrous reproductive system with increased ovarian interstitial formation and failure in follicular maturation and growth. The preputial glands have two cytologically distinct parts, and the more distal and distinctive of these appears to be most sensitive to stressful environmental conditions. The functional correlations of these findings are discussed and notable features in the microanatomy of the reproductive system are described.

LITERATURE CITED

Alden, R. H. 1942. The periovarial sac in the albino rat. Anat. Rec., 83: 421–435.

Allen, E., T. B. Thomas, J. G. Wilson and D. A. Hession. 1943. Differential growth

in the ovaries and genital tract near the time of ovulation in rats treated with colchicine. Amer. Jour. Anat., 72: 291–337.

ARAI, H. 1920. On the postnatal development of the ovary (albino rat), with especial reference to the number of ova. Amer. Jour. Anat., 27: 405.

BRAMBELL, F. W. R. AND I. W. ROWLANDS. 1936. Reproduction of the bank vole (*Evotomys glareolus* Schreber). I. The oestrous cycle of the female. II. Seasonal changes in the reproductive organs of the male. Philos. Trans. Roy. Soc. London, Ser. B, 226: 71–120.

DORFMAN, R. I. AND R. A. SHIPLEY. 1956. Androgens, biochemistry, physiology, and clinical significance. John Wiley and Sons, New York.

GREEN, S. H., A. M. MANDL AND S. ZUCKERMAN. 1951. The proportion of ovarian follicles in different stages of development in rats and monkeys. Jour. Anat., 85: 325–329.

HARMON, M. T. AND H. D. KIRGIS. 1938. The development and atresia of the Graafian follicle and the division of the intra-ovarian ova in the Guinea pig. Amer. Jour. Anat., 63: 79–99.

KELLOGG, M. 1945. The postnatal development of the oviduct of the rat. Anat. Rec., 93: 377–399.

MAQSOOD, M. 1952. Thyroid functions in relation to reproduction of mammals and birds. Biol. Rev., 27: 281–319.

MONTAGNA, W. AND C. R. NOBACK. 1946. The histology of the preputial gland of the rat. Anat. Rec., 96: 41–54.

QUAY, W. B. AND J. F. QUAY. 1956. The requirements and biology of the collared lemming, *Dicrostonyx torquatus* Pallas, 1778, in captivity. Säugetier. Mitt., 4: 174–180.

RAUSCH, R. 1953. On the status of some arctic mammals. Arctic, 6: 91–148.

SCHAFFER, J. 1940. Die Hautdrüsenorgane der Säugetiere mit besonderer Berücksichtigung ihres histologischen Aufbaues und Bemerkungen über die Proktodäaldrüsen. Urban and Schwarzenberg, Berlin and Wien.

SCHMIDT, I. E. 1942. Mitotic proliferation in the ovary of the normal guinea pig treated with colchicine. Amer. Jour. Anat., 71: 245–270.

STANLEY, A. J. AND R. A. POWELL. 1941. Studies on the preputial gland of the white rat. Proc. Louisiana Acad. Sci., 5: 28–29.

WIMSATT, W. A. AND C. M. WALDO. 1945. The normal occurrence of a peritoneal opening in the bursa ovarii of the mouse. Anat. Rec., 93:47–53.

Dept. of Zoology, Univ. of California, Berkeley. Received 15 June 1958.

ANATOMY OF THE DIGESTIVE TRACT OF *MICROTUS*

BY FRANK B. GOLLEY

In a recent investigation of the energy flow through the old-field vegetation : meadow vole (*Microtus pennsylvanicus*) : least weasel (*Mustela rixosa*) food chain, the writer showed that *Microtus* had an unusual ability to digest herbaceous vegetation (Golley, 1958). In feeding experiments with alfalfa or lettuce, carrots and oatmeal, only 10 to 14 per cent of the gross food energy was recovered in the feces. Most of the remaining food energy presumably was used by the mice. In comparison, cattle and sheep have a digestive

efficiency of approximately 50 per cent when fed a diet of alfalfa (Morrison, 1949). The unusual digestive efficiency of *Microtus* may be the result of (1) the structure of the digestive tract allowing greater utilization of herbaceous food material, (2) a particularly efficient enzyme system, or (3) the presence of an intestinal flora and fauna which assist in the breakdown of cellulose. This paper is concerned only with the digestive tract structure.

As far as is known, there has been no complete anatomical study of the digestive tract of any form of the genus *Microtus*. Some European workers (Fleischman, 1891; Retzius, 1841; Sulc, 1930; Topfer, 1891; Velicko, 1939; Weber, 1927) have studied the stomach and esophagus of several European species of *Microtus* but, apart from these, this important genus has been almost ignored.

Since the meadow vole is primarily an herbivore—insect remains appearing in trace amounts, in the stomach samples collected at all seasons of the year—it might be expected that the digestive tract would include the elaborate stomach, capacious caecum, and relatively long large intestine characteristic of other herbivores. Further, based on Mitchell's (1905) study of the intestinal tracts of representative rodents, including the rat (*Rattus norvegicus*) and the hamster (*Cricetus cricetus*), we would also expect *Microtus* to possess a distinct duodenal loop, an elongated Meckel's tract (the distal portion of the small intestine), a large, spirally coiled caecum, and a large intestine, differentiated at the proximal end into two colic loops. It was the purpose of this study to examine these assumptions and then, by considering the microscopic anatomy of the digestive tract, to determine the relationship between structure of the digestive tract and the observed high digestive efficiency in this species.

Methods.—The gross anatomical description is based on the digestive tracts, excluding the teeth, salivary glands, pancreas and gall bladder, of two freshly killed, adult *Microtus*. Freehand, diagrammatic drawings of selected portions of the digestive tract were made from this fresh material. A series of five digestive tracts from other adult meadow mice were sectioned for histological examination. In each instance, the digestive tract was removed immediately after the mouse was killed and was fixed in formalin or Bouin's fixative. After fixation, the tissues were stored in 70 per cent alcohol. The usual Harris' haematoxylin and eosin staining technique was employed. One tract was sectioned serially; the others provided information in specific regions where there was a question of interpretation.

GROSS ANATOMY OF THE DIGESTIVE TRACT

The mouth.—Immediately caudad to the incisors there is a thickening of the cheek, which forms the oral sphincter pad. As in most rodents, this pad serves to close the mouth. The terminal portion of this oral sphincter pad is raised and thickly covered with bristles (Fig. 1, left). Just posterior to the pad, a second bristle area is evident. On this raised area, as on the oral sphincter pad, the bristles are directed posteriorly.

The ridging on the roof of the mouth is separated into two areas. First,

the diastemal ridging between the incisors and the molars is composed of a short, narrow ridge, parallel to the long axis of the skull, and a series of transverse ridges. The narrow, parallel ridge runs from the base of the incisors to a transverse crest located approximately midway in the diastema. Two transverse ridges run medio-anteriorly toward this crest. Four additional transverse ridges follow. The first and second of these are continuous across the roof of the mouth, while the remaining two curve medio-posteriorly around the first molar.

Second, the palatal ridging, present between the molar teeth, is composed of two series of four transverse ridges, one series on each side. These ridges are separated by a medial sulcus. The first two series curve medio-posteriorly, while the second two curve medio-anteriorly.

Following the ridging described above, a series of small folds is found immediately before the opening into the esophagus.

The teeth consist of one pair of incisors and three pairs of molars in both upper and lower jaws. Since the teeth of this rodent have been used as taxonomic criteria, they have been described fully by other authors (Decoursey, 1957; Hinton, 1926) and will be omitted from this discussion.

The tongue is quite large and entirely fills the mouth cavity (Fig. 1, right). A slight groove is evident at the apex linguae and the dorsum is slightly constricted where the tongue touches the molar teeth on each side. Immediately posterior to this constriction an elliptical prominence rises above the surface of the dorsum, separated from the dorsum by a transverse depression. Posteriorly, the prominence curves medially toward a circular vallate papilla. The third of the tongue anterior to the constriction of the dorsum is free from the floor of the mouth.

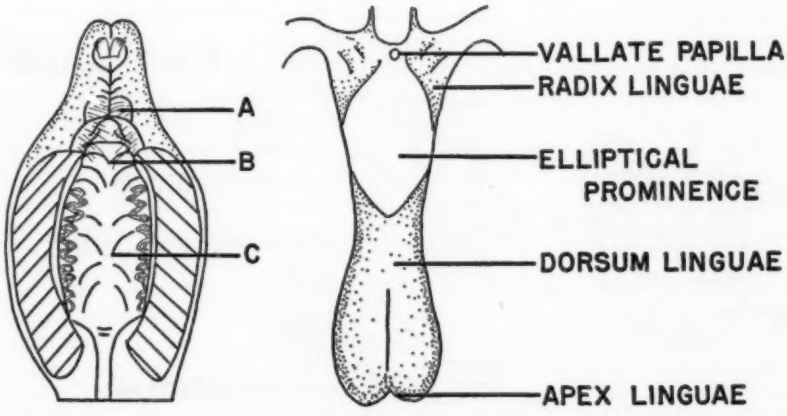


FIG. 1.—LEFT: ventral view of palatal region, with lower jaw removed—*A*, terminal bristle region of oral sphincter pad; *B*, diastemal ridging on roof of mouth; *C*, palatal ridging between molar teeth. RIGHT: dorsal view of tongue.

The digestive tract.—The esophagus is seen as a narrow tube extending from the mouth to the stomach. It averages approximately 30 mm. in length.

The stomach is a U-shaped organ which may be divided into three areas, an esophageal sac, fundic gland, and pyloric stomach (Fig. 2, left). The esophageal sac is apparently a continuation of the esophagus and contributes the largest portion to the total mass of the stomach. This sac may appear especially large when extended with food. A fundic gland occupies the greater curvature of the stomach and appears dark red in color and very thick and fleshy. Between the fundic gland region and the esophageal sac are a number of teeth-like fimbria (*Grenzfalten*, Bensley, 1902) extending into the stomach cavity. Finally, the pyloric region makes up the distal portion of the stomach and extends proximally on the dorsal surface toward the lesser curvature.

Food taken from the esophageal sac generally retains its green appearance, since gastric secretions have not yet acted on the plant-cell walls. However, in the fundic and pyloric regions digestion has begun and the cells have lost their chloroplasts. In the pyloric stomach, especially, the food material is a watery, brownish mixture.

The small intestine is a relatively large tube, averaging approximately 360 mm. in length and 3 mm. in diameter. As in many mammals, it can be divided into a duodenum and a Meckel's tract (Mitchell, 1905). A large duodenal loop is present (Fig. 2, right) while Meckel's tract is only slightly coiled and folded.

The caecum in *Microtus pennsylvanicus* is the dominant structure of the digestive tract. When the body cavity is opened by a ventral incision this structure fills the posterior half of the cavity and conceals the other organs beneath it. As anticipated, the terminal portion of the caecum is tightly coiled.

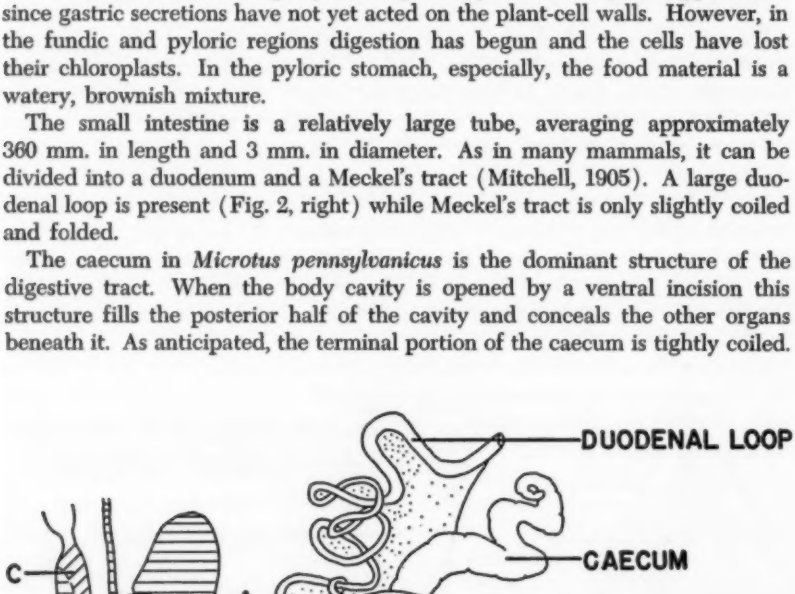


FIG. 2.—LEFT: diagram of stomach—*A*, esophagus and esophageal sac, lined with stratified squamous epithelium; *B*, fundic gland region; *C*, pyloric stomach. RIGHT: diagram of intestinal tract, with caecum partially uncoiled.

The length of the extended caecum, from the terminal curve to the colic loops, averages 110 mm. The diameter is exceedingly variable and depends on the quantity of contained material. Internally, the caecum presents a series of complex folds which may serve to increase the surface area of the organ. The small intestine enters the caecum at a right angle and is separated from the three distinct colic loops by a short neck.

The colon-rectum, extending from the colic loops to the anus, averages approximately 156 mm. in length and is generally narrower in diameter than the small intestine. Fecal pellets are formed approximately midway between the colic loops and the anus.

The liver may be divided into a series of lobes. The large anterior left lobe is composed of a right and left portion. The medial left lobe is relatively narrow and lies between the large right portion of the anterior left lobe and the expanded posterior left lobe, which overlies the kidney. On the right side of the body, the anterior lobe is again the largest, while the medial and posterior lobes are quite small and leaf-like.

MICROSCOPIC ANATOMY OF THE DIGESTIVE TRACT

Tongue.—The striated muscles of the tongue run in several directions and are separated into bundles by connective tissue, containing adipose tissue, tubuloalveolar glands and blood vessels. Fungiform, filiform and vallate papillae appear on the surface.

Papillae are found on all surfaces of the tongue in the anterior region. On the dorsum, filiform papillae are especially abundant, while on the ventral surface fungiform papillae are most common. In the region of the elliptical prominence, papillae almost disappear from the dorsum. Filiform papillae persist on the edges and may extend ventrally as far as the transverse depression. At the posterior border of the elliptical prominence one vallate papilla is located on the dorsal surface in the midline. This papilla has a true connective tissue core and does not project above the surface of the tongue. Taste buds occur on the lateral border of the vallate papilla, at the floor of the trench surrounding the papilla and on the adjoining surface of the body of the tongue bordering the papilla. These taste buds extend about one-third of the way toward the dorsal surface of the tongue on both the papilla and its borders. Ducts of serous glands also enter the trench. Apparently, there are no foliate papillae in *Microtus pennsylvanicus.*

In the anterior region of the tongue the muscle layers are arranged in three directions; a layer of circular muscle underlies the epithelium, while longitudinal and transverse muscle bundles are present in the interior. Posteriorly, these three sets of muscles are underlain by a series of large longitudinal muscle bundles which comprise the main body of the tongue. In this region, too, the layers of transverse muscle bundles are particularly evident.

Among the muscle bundles are a number of tubuloalveolar glands. These glands first appear immediately before the elliptical prominence and become

more abundant posteriorly. The glands among the most dorsal longitudinal muscle bundles appear to be composed of serous cells, while those located more laterally and ventrally in the transverse muscle bundles appear to be mucous in nature.

Esophagus.—At the level of the pharnyx, the epithelium of the esophagus consists of approximately seven layers of stratified squamous cells. In the mid-region of the esophagus, the epithelium and its cornified layer increases in depth, while toward the esophageal sac the epithelium decreases in height to about four or five layers of cells. The muscularis mucosae becomes evident in the mid-region of the esophagus and consists of only a few layers of muscle fibers. More posteriorly the muscularis mucosae appears as a thick, inner spiral and an outer circular layer. Glands appear very irregularly in the mucosa near the pharynx and are absent throughout the remainder of the esophagus. The tunica muscularis consists of an inner circular and an outer longitudinal layer. Striated muscle fibers appear in the tunica muscularis throughout the esophagus and appear to be most prevalent near the esophageal-cardiac junction. In the mid-region of the esophagus striated muscle makes up approximately half of the muscle fibers. The tunica serosa appears generally as a single layer of mesothelial cells.

Stomach.—The stomach may be divided into three distinct regions by histological, as well as by gross, examination. In the esophageal sac region of the stomach the epithelium is highly folded, even exhibiting a branched appearance in some areas (Plate I, 1). This epithelium consists of two or three layers of stratified squamous cells. A thin muscularis mucosae appears to rest on a tunica muscularis of two layers. The inner layer of the tunica muscularis consists of bundles arranged circularly, and the outer is composed of longitudinal fibers. The tunica muscularis comprises approximately ⅕ of the total depth of the stomach wall. Altogether, the stomach wall in this region gives an appearance of relative thinness. At the junction of the esophageal sac and the fundic stomach the leaf-like fimbria or Grenzfalten are composed of several layers of stratified squamous epithelium on a connective tissue core (Plate I, 2).

The fundic region of the stomach is a very thickened area as compared with the esophageal stomach (Plate I, 3). The mucosa increases in height approximately four times and from the bottom of the glands to the bottom of the surface crypts is about 60 to 70 cells in depth. The surface crypts are relatively narrow and shallow and are lined with simple columnar epithelium. With the haematoxylin and eosin stains, continuous columns of dark blue- and pink-staining cells can be identified. Near the surface of the stomach, the pink-staining cells are more abundant and interrupt the blue columns. These pink

---

Photographs of digestive tract of *Microtus*. 1, Esophageal-sac region of stomach; × 40. 2, Junction of esophageal sac and fundic stomach, showing fimbria or Grenzfalte; × 22. 3, Fundic gland region of stomach; × 14. 4, Pyloric region of stomach; × 30. 5, Duodenum, showing large numbers of Brunner's glands; × 30. 6, Small section of caecal epithelium, showing highly folded character; × 40.

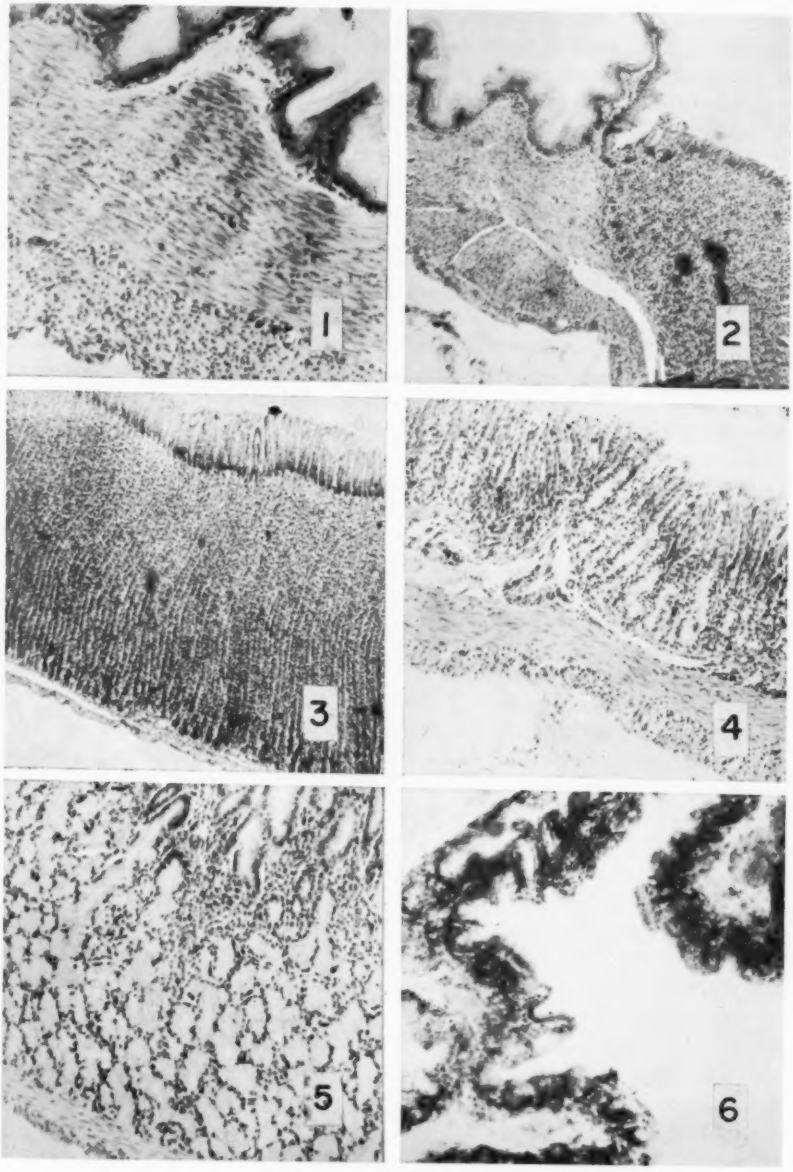


PLATE I

Legend opposite.

cells were identified as parietal cells, while the blue cells were considered to be chief cells. This interpretation was made on the basis of the discussion of the stomach of the domestic pig (*Sus scrofa*) by Sloss (1954).

In the fundic region the circular layer of muscle, which forms the major part of the tunica muscularis in the esophageal sac, decreases in depth, while the outer layer of longitudinal muscle continues unchanged. At the region of transition of the esophageal and fundic stomachs an additional layer of longitudinal muscle appears, interior to the circular bundles.

The gastric glands in the pyloric stomach are shorter and less closely arranged than in the fundic stomach (Plate I, 4). The gastric pits may be quite short and the glands, which are made up of one cell type, may branch irregularly. However, the great majority of glands are unbranched. The total mucosa is narrower in depth and is less dense than the mucosa of the fundic stomach. A muscularis mucosae is present. The tunica muscularis is composed of three muscle layers; in the same section an inner oblique, medial circular, and an outer longitudinal layer may be observed. A single layer of cells forms the tunica serosa.

Small intestine.—On the basis of histological criteria, the small intestine may be divided into duodenum, jejunum and ileum. The transition from the stomach to duodenum is gradual when only the mucosa is considered. The mucosa of the duodenum is lined by simple columnar cells and is approximately half the height of the pyloric mucosa. The villi are short and broad and are lined by regular rows of columnar cells, with a few goblet cells scattered throughout the epithelium. Below a poorly developed muscularis mucosae the glands of Brunner are abundant (Plate I, 5). These mucous-like glands appear abruptly and serve to distinguish the duodenum from the stomach. Brunner's glands form a ring beneath the mucosa and may be twice as thick as the mucosa. Proceeding posteriorly, the glands of Brunner decrease in height but maintain their continuity around the duodenum. The tunica muscularis is made up of an inner circular and an outer longitudinal muscle layer.

In the jejunum the villi increase in depth and plicae circulares appear among the simple columnar cells of the epithelium; goblet cells become more numerous. Goblet cells occur only irregularly in the intestinal glands, while cells of Paneth are seen regularly. The muscularis mucosae is more prominent than in the duodenum and the submucosa is much less developed. In the tunica muscularis the inner circular muscle layer is approximately twice as thick as the longitudinal muscle layer.

In the ileum the villi increase greatly in height, while the plicae circulares disappear. The crypts of Lieberkuhn are quite deep, whereas the intestinal glands are only poorly developed and are quite shallow. The intestinal glands are lined with simple columnar epithelium and few goblet cells are found in the glandular epithelium. The crypts comprise approximately 80 per cent of the depth of the mucosa. The submucosa and muscularis mucosae are less developed than in the jejunum. In certain areas the submucosa contains large

lymph nodules (Peyer's patches). The villi covering these nodules are shorter than on adjacent regions of the ileum. The tunica muscularis has an inner circular layer and outer longitudinal layer which are of equal depth. The tunica serosa, as in the duodenum and jejunum, is composed of a thin layer of connective tissue and mesothelial cells.

Large intestine.—The caecum is unusual in several respects. First, almost no goblet cells are found in the columnar epithelium lining the mucosa (Plate I, 6). Second, the plicae circulares are well developed. These plicae are higher and more branched than those observed in the jejunum. The submucosa is quite thin in most areas, but may be expanded to include lymph nodules. The inner circular layer of the tunica muscularis may continue into the plicae, while the thin, outer, circular layer is highly convoluted. On the wall of the caecum the outer muscle layer may be expanded to form the taenia coli. The tunica serosa is like that of the small intestine.

In general the colon displays a structure similar to that of the caecum. In the region of the colic loops the plicae circulares are less abundant but still highly developed. Among the columnar epithelium at the base of the intestinal glands are a moderate number of goblet cells. These goblet cells do not, however, extend toward the surface of the glands. The muscularis mucosae is evident as a narrow line of muscle fibers and the tunica propria is particularly apparent in the region of the plicae. The muscularis mucosae is slightly narrower than in the region of the caecum.

In the anterior and medial portions of the rectum the rectal glands are lined with columnar epithelium. Goblet cells are generally absent in this region. The plicae disappear, while the glandular crypts become greatly elongated and give the tract an appearance much like that of the ileum. The tunica propria and muscularis mucosae are but poorly developed. The tunica muscularis continues as an inner circular and outer longitudinal muscle layer, and remains approximately the same thickness as in the colon.

In the posterior portion of the rectum the well-developed rectal glands appear as long straight tubes and are lined with columnar cells; goblet cells are generally absent. The muscularis mucosae is highly developed and appears to consist of both longitudinal and circular smooth muscle fibers. The tunica propria is only slightly developed, while the tunica muscularis continues to display the same characteristics as the anterior and medial portions of the rectum.

The simple columnar epithelium of the rectum changes abruptly to stratified squamous epithelium at the anus. A cornified layer of cells is also prominent above the five to seven layers of squamous cells. A layer of circular smooth muscle fibers is present immediately below the mucosa. Numerous hair follicles occur near the exterior of the digestive canal. In the tunica propria, anal glands form a circular layer completely around the lumen. The anal glands are, in turn, surrounded by the striated fibers of the anal sphincter muscles.

DISCUSSION

An examination of the digestive tract of *Microtus pennsylvanicus* reveals an average rodent tract as rescribed by Howell (1926), Mitchell (1905), Topfer (1891), Bensley (1905) and others. The extensible esophageal sac is found in many rodents and is used to store food prior to digestion. This provision for food storage probably allows the rodent to take advantage of favorable food sources available momentarily and also to gather food and retire to a place of concealment while digestion occurs. The stomach of *Microtus* is closely similar to that of the muskrat (*Ondatra*) according to Bensley (1905), since the greatest portion of the gastric epithelium is composed of stratified squamous epithelium. The fundic gland and pyloric stomach are considerably reduced in these two microtines.

The absence of goblet cells throughout the intestinal tract, generally, may be considered unusual, since we would expect to find large numbers of these mucous-secreting cells in the ileum, caecum and colon. The fixation and staining techniques used in this study may have obscured this cell type.

A comparison of the total length of portions of the digestive tract in *Microtus* with those in *Neotoma,* an herbivorous wood rat (Howell, 1926), is shown below:

	Per Cent of Total Length	
	Microtus	*Neotoma*
Small intestine	58	46
Caecum	18	7
Large intestine	24	47

This indicates that the caecum is unusually long and the colon-rectum unusually short in *Microtus,* as compared with *Neotoma.* This large caecum may serve as a storage place for food materials, where further microbial digestion may occur. The highly branched plicae of the caecum increase the surface area and probably provide for greater absorption of metabolites made available by the action of the caecal flora and fauna. The colic loops and rectum also may serve an absorptive function.

This examination of the digestive tract of *Microtus pennsylvanicus* indicates that, although the tract is typical of herbivores in general, it has no one structural difference which would permit digestion of herbaceous food at the observed high efficiency. The large caecum, with elaborately folded walls, is probably a contributing factor, but the primary cause of the high digestive efficiency will probably be discovered in a study of the intestinal flora and fauna.

SUMMARY

In previous experiments, *Microtus pennsylvanicus* was observed to have an unusually high digestive efficiency on alfalfa and lettuce, carrot, and oatmeal diets. The anatomy of the digestive tract was studied to determine if there was some anatomical reason for the high efficiency of digestion of herbaceous foods. Gross and histological examination revealed that the digestive tract of this rodent was typical of other herbivorous rodents in general, since it

possessed a large duodenal loop, large, spirally coiled caecum, and colic loops. The tract was unusual in having few goblet cells in the small and large intestine and caecum and elaborately folded caecal walls. It was concluded that the anatomy of the digestive tract was probably not the causative factor for the observed high digestive efficiency.

LITERATURE CITED

BENSLEY, R. R. 1905. The cardiac glands of mammals. Amer. Jour. Anat., 2: 105–156.

DECOURSEY, G. E., JR. 1957. Identification, ecology and reproduction of *Microtus* in Ohio. Jour. Mamm., 38: 44–52.

FLEISCHMAN, A. 1891. Bemerkungen über den Magen der Rodentia. Morph. Jahrb. Leipz., 17: 408–416.

GOLLEY, F. B. 1958. Energy dynamics of a food chain of the old-field community. Ph.D. Thesis, Michigan State University. 102pp.

HINTON, M. A. C. 1926. Monograph of the voles and lemmings (Microtinae). Vol. 1. British Mus. (Nat. Hist.). 488 pp.

HOWELL, A. B. 1926. Anatomy of the wood rat. Williams and Wilkins, Baltimore. 225 pp.

MITCHELL, P. C. 1905. On the intestinal tract of mammals. Trans. Zool. Soc. Lond., 17: 438–536.

MORRISON, F. B. 1949. Feeds and feeding. 21st ed. Morrison Publ., Ithaca, N.Y. 1,027 pp.

RETZIUS, A. 1841. Ueber den bau des Magens bei den in Schweden vorkommenden Wuhlmausen. Arch. f. Anat., Physiol. u. Wissench. Med., Berlin, 8: 403–420.

SLOSS, M. W. 1954. The microscopic anatomy of the digestive tract of *Sus scrofa domestica*. Amer. Jour. Vet. Res., 15 (57): 578–593.

SULC, K. 1930. Changes in the wall of the stomach of the field mouse (*M. arvalis*) caused by the parasitic strongylid, *H. polygyrus*. Spizy. Lekarske Fak. Masarykovy Univ. Brne. 9 (11): 123–126. [From Biol. Abstr.]

TOPFER, K. 1891. Die Morphologie des Magens der Rodentia. Morph. Jahrb. Leipz., 17: 380–407.

VELICKO, M. A. 1939. On some peculiarities of structure of esophagus and stomach in wild rodents. Arch. Russ. Anat., Hist. et Embryol., 20 (2): 363–376. [From Biol. Abstr.]

WEBER, M. 1927. Die Säugetiere. Vol. 1., 2nd Ed. Gustav Fischer, Jena. 444 pp.

Dept. of Zoology, Univ. of Georgia, Athens. Received 9 July 1958.

LABORATORY AND FIELD STUDIES OF THE NORTHERN GRASSHOPPER MOUSE

By HAROLD J. EGOSCUE

In Utah the northern grasshopper mouse, *Onychomys leucogaster utahensis* Goldman, is one of several subspecies of small mammals peculiar to the Bonneville Basin, a well-defined physiographic subdivision of the eastern Great Basin (Durrant, 1952: 502). Here, as elsewhere, grasshopper mice usually are not abundant; the accumulation of notes and specimens is slow and often obtained coincidental to other projects. Most references to this species are in various faunal reports and shorter papers on food habits, records of occurrence and extensions of ranges. Much of the precise knowledge concerning its

foods and general habits is contained in the valuable and frequently quoted contributions by Bailey (1929), Sperry (1929), and Svihla (1936). Russell and Findley (1954) provided an observation on the swimming ability of *Onychomys leucogaster*. In the last systematic account of the genus, Hollister (1914) recognized 12 subspecies of the northern grasshopper mouse; 15 races are listed in the latest catalogue of North American mammals (Miller and Kellogg, 1955). None of the published data on reproduction known to the writer refers to specimens from Utah.

The primary aims of this study were (1) to develop methods for raising the mouse in captivity, (2) to determine its breeding cycle and reproductive potential, and (3) to contribute toward a better understanding of the role this little-known rodent might play in an epizootic.

Acknowledgment is made to E. Ekker, B. N. Day and J. G. Bittmenn for dependable laboratory assistance, and to E. A. Shippee, D. D. Parker and J. P. Newey for supplying many of the grasshopper mice used to start the original colony. Thanks are extended to the many members of the Ecological Research staff (both military and civilian) for a number of useful suggestions during this study. S. D. Durrant critically read the manuscript and suggested several improvements in the text.

MATERIALS, METHODS AND PROCEDURES

This paper is based largely upon records of reproduction in the laboratory of 43 females, supplemented by other data deemed to be new or of significance to the present account. Breeding habits of grasshopper mice are compared with those of several common rodents of western Utah in an attempt to offer some explanation of the general relative scarcity of grasshopper mice.

The rearing methods reported herein were developed at the University of Utah's Ecological Research Faunal Laboratory at Dugway, Utah, where approximately 1,000 grasshopper mice were reared for experimental studies during the period 1953–1957. The colony was established with animals captured in south-central Tooele County, using Havahart and tin-can traps baited with grain. Most of the mice adjusted to laboratory conditions, but only those animals that appeared to be least affected by captivity were selected for breeding stock. They were paired permanently unless incompatible; less strife and mortality resulted if both animals were about the same age. Breeding pairs and weaned litters were housed in galvanized metal pens 18 × 13 × 8 inches equipped with heavy mesh lids, water bottles and feeders for pellets. About 1 inch of fine sand was provided for dust bathing and to absorb liquids; a cheap grade of cotton furnished nesting material.

At weaning time, or shortly thereafter, litters were removed from the breeding cages; at first, 8 to 10 mice of the same sex were placed in a cage, an arrangement that has proved satisfactory for deer mice (Egoscue, 1955: 52). This, however, brought together grasshopper mice of different litters and slightly different sizes and ages, which often resulted in considerable mortality among

the smaller, younger animals. These losses were reduced substantially by housing each litter separately as a unit.

Once a week breeding pairs and any unweaned young were fed 3–4 ounces of a grain mixture composed by volume of 60 per cent rolled oats or barley, 20 per cent alfalfa hay leaves, 10 per cent pigeon mix (corn, wheat, milo, vetch, kafir, peas), and 10 per cent sunflower seeds. The dry diet was supplemented by a weekly feeding of about 1 tablespoon of canned dog food, a small piece of raw carrot dipped in cod liver oil, and a slice of orange. Greater or lesser amounts were fed to weaned animals depending on the number per cage. Commercial mouse pellets were supplied *ad libitum*. The birth date, litter size, sex of young, and deaths were recorded for all litters. The few outbreaks of ectoparasites were easily controlled with rotenone sprinkled sparingly from a salt shaker into infested nests and cages.

Field data on grasshopper mice were obtained during the course of routine live-trapping for other rodents. A few of the wild-trapped grasshopper mice were killed and examined for ectoparasites and breeding condition. A small number were prepared as conventional study specimens.

All localities mentioned are in Tooele County, Utah.

RESULTS AND DISCUSSION

Habitat and associated mammals.—Grasshopper mice are widely distributed but generally are uncommon to rare in the northern Booneville Basin. Altitudinally, they were collected from about 4,250 feet along the eastern margin of the Great Salt Lake Desert to 6,000 feet on Johnson Pass between the Stansbury and Onaqui mountains. No clear-cut habitat preferences were detected, although the mice appeared to avoid marshy areas, extremely rocky situations, precipitous hillsides, the extensive but generally featureless shadscale (*Atriplex confertifolia*) flats with their alkaline soils, and the pickleweed (*Allenrolfia occidentalis*) hummocks. This last is a salt-tolerant type of vegetation consisting virtually of a single species and supports an extremely low resident mammal population. Edaphic requirements which include conditions permitting frequent dust bathing may restrict the ecological distribution of grasshopper mice more than other physical factors of the environment. In captivity this penchant for cleansing the fur must be satisfied, otherwise the mice do not thrive, become oily in appearance and extremely uncomfortable. Grasshopper mice were most common on semi-stabilized dunes of fine, windblown sand along the valley floors and foothills where the vegetation was some combination of four-winged saltbrush (*Atriplex canescens*), rabbit brush (*Chrysothamnus* sp.), buckwheat (*Eriogonum dubium*), horsebrush (*Tetradymia* sp.), greasewood (*Sarcobatus vermiculatus*), Indian rice grass (*Oryzopsis hymenoides*), and other grasses and a few annual herbs. In a line of 50 tin-can traps set for 5 days in the latter part of July 1953, along a dune at the north base of Little Granite Mountain, two grasshopper mice and 36 other rodents (22 *Dipodomys ordi*, 2 *Microdipodops megacephalus*, 11 *Reithrodontomys megalotis*, 1 *Peromyscus maniculatus*) were obtained. At the same locality,

during a period of inclement winter weather that featured subfreezing temperatures, snow, and high winds, 55 tin-can traps, set intermittently without moving the line for a total of 14 days from 29 November 1955 to 4 January 1956, caught two grasshopper mice and 127 other small mammals (60 *Peromyscus maniculatus*, 59 *Reithrodontomys megalotis*, 8 *Dipodomys ordi*). Other rodents captured at this locality, but not represented in the above catches, were *Perognathus longimembris* (in warmer months), *Citellus leucurus*, and *Thomomys bottae*.

Along the bottom of a dry canyon (elevation 5,800 feet), 3 miles southwest of the small mining community of Gold Hill near the north end of the Deep Creek Mountains, a line of 200–280 tin-can traps set from 20–24 August 1956 captured one subadult grasshopper mouse and 81 other rodents (38 *Peromyscus maniculatus*, 20 *Reithrodontomys megalotis*, 7 *Neotoma lepida*, 2 *Dipodomys microps*, 10 *Perognathus parvus*, 4 *Citellus leucurus*). At this locality, the dominant plants were black sage (*Artemisia tridentata nova*), shadscale (*Atriplex confertifolia*), small rabbit brush (*Chrysothamnus* sp.), snakeweed (*Gutierrezia diuaricata*), and giant wild rye (*Elymus condensatus*). Juniper trees (*Juniperus utahensis*) occurred along the canyon sides, but only a few very small ones extended into the floor of the canyon. The soil was typical of desert canyons which experience cloudburst and near-cloudburst run-offs, and consisted of shallow to rather deep, more or less structureless mixtures of silt, sand, gravel, and boulders along the sparsely vegetated main channel. Some loam and finer sands deep enough to support fair to heavy stands of vegetation occurred along the banks of the wash.

Fleas and lice.—The ectoparasites from grasshopper mice provide circumstantial evidence that these mice directly and/or indirectly come in contact with other rodents and suggest a few of the many potential routes an epizootic might spread through an assemblage of mammals.

Species of fleas collected from *Onychomys leucogaster* trapped in western Utah (Parker and Howell, unpublished MS, 1957) are presented in Table 1, together with what is considered the preferred host of each flea for the area. This list agrees very closely with Hubbard's (1949) general host preference classification for these fleas (see also Table 1). Hubbard, however, considered *Monopsyllus exilis* to be a true grasshopper mouse flea.

Sucking lice collected from grasshopper mice and other mammals from the vicinity of the Great Salt Lake Desert were reported by Ignoffo (1956). Two kinds of lice, *Hoplopleura hesperomydis* and *Hoplopleura arboricola*, were found on *Onychomys*. *Hoplopleura hesperomydis* was also collected from five other rodents—*Mus musculus*, *Perognathus formosus*, *Peromyscus crinitus*, *Peromyscus maniculatus* and *Peromyscus truei*; while *H. arboricola* was collected from three other rodents—*Citellus townsendi*, *Eutamias dorsalis* and *Eutamias minimus*.

Reproduction.—Grasshopper mice bred readily in captivity. Most females were seasonally polyestrous, the period extending from January through July;

TABLE 1.—*Fleas collected from grasshopper mice in western Utah, with comparison of host preferences obtained from two sources*

SPECIES OF FLEA	PREFERRED HOST	
	Western Utah (Parker and Howell, 1957)	Western United States (Hubbard, 1947)
Dactylopsylla comis Jordan	unknown	pocket gopher
Foxella ignota (Baker)	Botta pocket gopher	pocket gopher
Hoplopsyllus anomalus (Baker)	antelope ground squirrel	ground squirrel
Malaraeus telchinum (Roths.)	unknown	deer mouse
Meringis parkeri Jordan	Ord kangaroo rat	kangaroo rat
Monopsyllus exilis (Jordan)	unknown	grasshopper mouse
Monosyllus w. wagneri (Baker)	deer mouse	deer mouse
Peromyscopsylla hesperomys (Baker)	*Peromyscus* sp.	deer mouse
Rhadinopsylla heiseri (McCoy)	antelope ground squirrel	antelope ground squirrel
Thrassis bacchi ssp.	antelope ground squirrel	antelope ground squirrel

approximately 89 per cent of the 116 litters produced by females with breeding records covering one or more calendar years were born from February through August (Fig. 1). *Estrus* normally followed parturition by a few hours or, at most, by a day or two. A few females exhibited a more irregular cycle where the heat period sometimes began at the regular time but at other times was delayed until after the current litter was weaned. One female bred within 3 hours after parturition. One to six young (average 3.54) were born following a gestation of 32–38 days for lactating females and 29–32 days for non-lactating females. Long gestation periods such as the 47-day pregnancy reported by Svihla (1936: 173) were not observed. Litter size frequency for 197 litters is summarized in Fig. 2.

Laboratory-reared grasshopper mice did not become sexually mature nearly as soon as did members of the genus *Peromyscus*; only one female from the single litter recorded for January produced young during the same year in which she was born. She was paired with an adult male on 12 April and gave

TABLE 2.—*Reproduction potentials of laboratory-reared Onychomys leucogaster compared with those of other rodent colonies in the same laboratory; values given are range and average*

SPECIES	NO. OF LITTERS	LITTER SIZE	LITTERS/YEAR	YOUNG/FEMALE/YEAR	LITTERS/LIFETIME
Onychomys leucogaster	205	1–6 (3.6)	1–10 (5.1)	2–37(18.3)	1–14 (7.6)
*Peromyscus maniculatus**	189	1–9 (4.5)	7–12(10.4)	15–63(41.3)	10–21(16.4)
Peromyscus truei	110	1–6 (3.6)	2–10 (6.8)	9–36(24.2)	4–16(11.5)
Neotoma lepida	211	1–5 (2.8)	2–9 (5.8)	3–26(15.6)	5–18(11.6)

* Only litters of wild trapped females used, as selection had increased reproductive rate among laboratory-born females.

birth to her first litter 11 July, when she was 191 days of age. Allowing 30 days for the average non-lactating pregnancy, this female first became gravid when she was about 160 days old. Other females did not mate until the breeding season following the year of their birth. If this long delay between birth and puberty is found to occur regularly among wild females, a most significant explanation for the general scarcity of grasshopper mice would be established. The possibility exists, of course, that a dietary or other deficiency is responsible for the temporary postponement of puberty in immature and subadult captives. Once breeding commenced, however, many females produced litters each breeding season for two or more years, so the deficiency, if any, must affect the estrous cycle of only the younger animals. Pregnancies among immature and subadult grasshopper mice are almost unknown. The pregnant individual 95 days of age reported by Svihla (*op. cit.*) constitutes the only example known to the writer where the mice bred before adulthood.

Grasshopper mice typically bore 3 to 6 litters (average 5) annually (Table 2). One extremely prolific individual bore 10 litters in a calendar year. Age of puberty and the reproductive cycle of the male is not known. The average reproductive lifetime of both sexes lasted from two to three years. Approximately 16 per cent of the pairs selected for breeding stock failed to produce young.

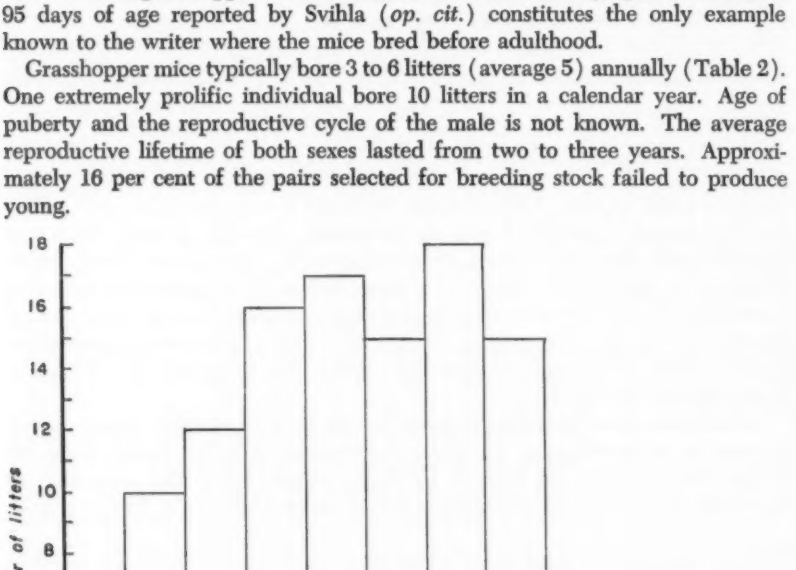


FIG. 1.—Schedule by months of 116 litters of grasshopper mice born to females with reproduction records covering one or more complete years.

The sex ratio, based on 181 litters (650 individuals) sexed at weaning, was 106 females to 94 males. Grasshopper mice were the only rodents among nine species bred in our laboratory with the secondary and the tertiary sex ratios in favor of females.

Data accumulated over an extended period suggest that wild adult grasshopper mice associate in pairs. Perhaps the relationship is rather casual and only apparent, rather than real, because the mice are scarce. Certainly such an arrangement would insure better opportunities for contact among animals during the breeding season, especially if the mice are as uncommon as trapping results indicate. In any event, during four years (1952–1956) of intermittent but fairly regular trapping, six pairs of adults were collected from an area of less than 2 acres. In two instances, the male and female were trapped the same night within a few feet of each other. At other times, a 1–3-day interval separated the two captures; it was then weeks, and sometimes as long as six months before another pair was taken, although an occasional immature or lone adult was trapped in the interim. The inference here is that when adults did reinvade the area, one of each sex usually appeared.

Only four wild-trapped female grasshopper mice were pregnant; all were large adults captured in May (1), June (2), and July (1). One contained six embryos and the others five embryos each. Additional collecting will no doubt extend the breeding season to include some earlier and possibly some later months.

Breeding habits of grasshopper mice contrast in several respects with those of other rodents with which they are associated. Many laboratory-born female deer mice, for example, reached the age of puberty when 6–7 weeks old and produced about 10 litters per year during the peak period of their reproductive lives, which averaged about 16 months. In the field, pregnant and lactating deer mice, some of which had not completed the subadult molt, were trapped at the lower elevations (4,500–4,700 feet) of Dugway Valley and environs in midwinter, as well as at other seasons. Field and laboratory studies indicate that some deer mice rear a litter before they are 90 days old, while most female grasshopper mice require six months or longer to reach breeding age.

Accordingly, the annual population curve of the grasshopper mouse drops with the cessation of reproduction in mid- or late summer. While all factors regulating the population dynamics of deer mice are not well understood, it it almost certain that mortality is offset by some reproduction throughout most of the year in the lower valleys and foothills. It is equally certain that reproduction during midwinter takes place only under the most favorable circumstances and probably involves an extremely small percentage of a given population. For example, only one of 24 females collected in January 1954, along a shallow gully at the north base of Camelback Mountain, showed evidence of breeding. This animal was captured in her nest located on the south-facing slope in a shallow depression filled to a depth of about 6 inches with dried leaves, bits of Russian thistle, and other debris; she was nursing four young less than a

week old. Other species whose breeding season extended into the late fall and winter months were the kangaroo rat, *Dipodomys ordi*, and harvest mouse, *Reithrodontomys megalotis*; both species bred in the laboratory as subadults. All three of the above species are common nocturnal rodents sharing many habitat requirements with grasshopper mice, but with much greater annual reproductive potentials.

The desert wood rat, *Neotoma lepida*, pinyon mouse, *Peromyscus truei*, (Table 2), and canyon mouse, *Peromyscus crinitus*, although not ordinarily associated with grasshopper mice ecologically in this area, are common nocturnal rodents with relatively shorter breeding seasons and/or lower birth rates than the grasshopper mice. The aforementioned three species also possess certain adaptive behavioral patterns thought to decrease the likelihood of predation, and possibly to increase their chances of survival, during climatic extremes. Pinyon mice and canyon mice, especially the latter, live and rear their young in rocky situations and in crevices of ledges or cliffs that provide more protection for the nest and more and better means of escape than exist

FIG. 2.—Litter size frequency and percentage of total of each size among 197 litters of *Onychomys leucogaster* born in captivity.

in habitats occupied by grasshopper mice. The relationship of homeostasis to survival in wood rats is well known.

Behavior.—In many details of behavior the grasshopper mouse departed from patterns common in other Cricetine rodents. Typically, its initial reactions to unfamiliar circumstances appeared to denote curiosity or, at most, cautious deliberation rather than apprehension. They seldom leaped blindly into space when attempting to escape as, for example, did canyon mice. They seldom displayed the nervous hesitancy about choosing an escape route so characteristic of wood rats suddenly confronted with strange territory. The females of many species of *Peromyscus* actively defend their young, especially nestlings, but none combined the vigor, persistence or effectiveness of grasshopper mice. The most vicious individuals sprang as far as 5 or 6 inches across the cage in successful efforts to bite. Males and immature animals were more passive and less prone to unprovoked attacks. Both young and old, however, resented being handled; some of the breeding stock particularly became adept at evading capture. As mentioned by Bailey (1936: 178), they usually depended more on agility than speed to escape. In captivity, adult grasshopper mice left their nests to investigate any disturbance that awakened them. Under similar circumstances most other species of mice usually remained hidden or sought to move deeper into the nest material and cage debris.

Senses.—Grasshopper mice are usually nocturnal; none were captured during the day. Bailey (1926: 82), however, observed and collected grasshopper mice of this species as late as 8:00 AM in North Dakota where he found they were less strictly nocturnal than white-footed mice, *Peromyscus leucopus.* Caged grasshopper mice spent all day in their nests unless disturbed or hungry; when well fed, they sometimes slept so soundly that routine noises failed to awaken them.

Presumably these mice can see well at night, but no practical tests were devised to compare their night vison with that of other mice. Their olfactory senses appear to be somewhat keener than those of *Peromyscus, Reithrodontomys* and *Neotoma.* On numerous occasions grasshopper mice convincingly demonstrated their ability to smell freshly killed insects and other foods not in sight. They usually reacted by sniffing in several directions before beginning a search for the source of the odor. The smell of dog food or fresh meat sometimes aroused them from an otherwise undisturbed sleep. Bailey (1929: 9) noted that his captives were quick to locate and dig up insects buried half an inch in the ground.

Their hearing is also acute and frequently helps to orient the mice when searching for prey such as beetles hidden in the cage debris.

An inquisitive or alert grasshopper mouse often sat erect for a moment or two with front paws held against the chest in a distinctive pose, reminiscent of ground squirrels such as *Citellus townsendi* and *C. armatus.*

Voice.—A variety of vocal utterances are characteristic of the grasshopper mouse. The high-pitched, prolonged call and a sharp, bark-like, rapidly

repeated note of alarm or anger have been commented on by Bailey (1929: 5–6) and others. Although both were frequently heard in the laboratory, the significance of the former is still undetermined, except that it was heard only from mature animals. The murmurings of undisturbed nestlings were quite audible and could be readily distinguished from those of deer mice, both by loudness and inflection of tone. Other vocal sounds included very low, bird-like chirping notes of protest made during feeding when two individuals were attempting to pick up the same food. When caught in live traps, grasshopper mice often advertised their presence by barking and chirping while the collector was still several yards from the trap.

Mortality factors.—During a study of raptorial birds in south-central Tooele County, R. D. Porter (unpublished data) recorded one grasshopper mouse among 57 prey items brought to nests by great horned owls, and one grasshopper mouse among 73 mammals brought to nests by red-tailed hawks. Bailey (1931: 140) records one mouse of this species in the stomach of a New Mexican desert fox, but thus far *Onychomys leucogaster* has not been identified among prey remains collected around den entrances or in fecal passages of the kit fox from this locality (Egoscue, 1956, and unpublished data). The general scarcity of these mice as well as their unimportance as food for coyotes is well illustrated by the results of a study conducted by Sperry (1941: 16); he recorded *Onychomys* only 11 times in 8,339 coyote stomachs examined. All except approximately 100 of the stomachs came from states within the geographic range of grasshopper mice. Possibly coyotes and foxes kill but do not commonly eat both species of grasshopper mice because of their musky odor.

In the laboratory, mortality resulted from various causes. Two females died during parturition. One of these was three years old and probably very near the end of her reproductive life. Fighting was uncommon in the breeding colony, but when it occurred females usually were the aggressors; four or five males were killed or later died from wounds inflicted during fights with females. One female killed three males in rapid succession. In each instance the pair mated and harmony prevailed until just prior to the birth of the first litter, when anxiety for the forthcoming young possibly prompted the female to kill the male. Mortality among grasshopper mice of pre-weaning age was a little higher than that of deer mice; mothers were responsible for a majority of these fatalities, which occurred most frequently in overcrowded cages.

Two old breeding females were troubled by a condition that caused them to hold their heads twisted grotesquely to one side and seriously affected their sense of balance. These symptoms are characteristic of mammals with middle ear infection, but at this writing both animals are still living, so a definite diagnosis has not been attempted.

Grasshopper mice appeared resistant to a usually non-fatal but growth-retarding ringworm infection (unidentified) that was also present in deer mice, wood rats and pinyon mice of pre-weaning age. Only one case of fungus was detected in the grasshopper mouse colony despite the fact that their cages

often were immediately adjacent to those housing deer mice with the infection. Aside from destroying all infected mice and disinfecting the cages in which they were found, no special precautions were taken to prevent the spread of this disease.

Outbreaks of ectoparasites among captive grasshopper mice were practically non-existent, although some serious infestations of parasitic mites, *Brevisterna utahensis,* and occasionally of fleas, *Orchopeas leucopus,* were found in the deer mouse, harvest mouse, wood rat and pinyon mouse colonies. When numerous, the mites caused considerable mortality among nestlings.

Tumors of the mammary region were unknown in grasshopper mice, while approximately 4 per cent of the older deer mice that had experienced 10 or more pregnancies developed spontaneous neoplasms involving the mammary glands (Egoscue and Day, 1958).

Food habits.—Data on food preferences were obtained by feeding various items to captives. Most of the results are duplicated in the more comprehensive list of Bailey (1929:13–15). Generally speaking, the mice preferred grasshoppers and related forms to all other arthropods. Darkling beetles (Tenebrionidae) of every kind also were eagerly eaten; the manner in which they handled the larger species is worthy of special comment. *Eleodes obscurus* and certain other large flightless tenebrionids are commonly called "stink beetles" because of the disagreeable musk they emit when disturbed. Their mode of defense always repelled the first dozen or so attacks by a grasshopper mouse, but either the beetles exhausted their supply of musk or the mice became accustomed to it, for all the encounters witnessed ultimately ended with *Eleodes* killed and eaten. Frequently the pungent fluid was discharged directly on the face of the grasshopper mouse, causing it considerable distress. Further attacks were temporarily postponed while the animal frantically rubbed and rolled in the sand attempting to rid itself of the irritating substance. In nature, such a potent defense might enable a beetle to escape before the mouse recovered. Almost all of the beetle was eaten, including hard parts; usually only portions of the legs and the distal half of the abdominal exoskeleton remained. The latter sometimes was noted in the field at localities where grasshopper mice were known to occur.

Captive grasshopper mice killed and ate all species of the smaller local cricetids and heteromyids offered to them. The majority of these were dispatched with bites that pierced the brain. Occasionally, however, a victim was strangled by seizing and holding it tightly by the throat. Carcasses of mice almost as large as the grasshopper mouse were picked up and carried with ease to a corner of the cage. An adult female pursued a deer mouse so intently that she finally failed to distinguish between her litter and the prey, killing one young and badly injuring another before they could be removed. Another grasshopper mouse required less than 6 minutes to capture, kill, and partially devour an adult deer mouse. Adults were more efficient killers than juveniles,

but a juvenile 30 days of age readily killed and ate a brown-shouldered lizard, *Uta stansburiana*.

Faint but unmistakable blood stains were noted on the throats and chests of several individuals at the time of capture—additional evidence that the natural diet of grasshopper mice includes small rodents and other vertebrates.

SUMMARY

Methods for maintaining a laboratory colony of northern grasshopper mice are given. In captivity this species bore 3 to 6 litters (average 5.09) annually; litter sizes ranged from 1 to 6 (average 3.54). Puberty in females was not attained until the mice were at least 160 days of age. Breeding habits and behavior of the northern grasshopper mouse in captivity are compared with several other cricetids from western Utah. A list of small mammals associated with the northern grasshopper mouse in two selected areas is included, together with data on habitat.

LITERATURE CITED

BAILEY, V. 1926. A biological survey of North Dakota. N. Amer. Fauna 49, 226 pp.

———. 1929. Life history and habits of grasshopper mice, genus *Onychomys*. Tech. Bull. 145, U.S. Dept. Agric.: 1–15.

———. 1931. Mammals of New Mexico. N. Amer. Fauna 53, 412 pp.

———. 1936. The mammals and life zones of Oregon. N. Amer. Fauna 55, 416 pp.

DURRANT, S. D. 1952. Mammals of Utah, taxonomy and distribution. Univ. Kansas Publ., Mus. Nat. Hist., 6: 1–549.

EGOSCUE, H. J. 1955. The faunal colony as a reservoir of native animals. *In* Symposium on ecology of disease transmission in native animals. Dugway, Utah: 50–54.

———. 1956. Preliminary studies of the kit fox in Utah. Jour. Mamm., 37: 351–357.

——— AND B. N. DAY. 1958. Orange-tan—a recessive mutant in deer mice. Jour. Heredity, 49: 189–192.

HOLLISTER, N. 1914. A systematic account of the grasshopper mice. Proc. U.S. Nat. Mus., 47: 427–489.

HUBBARD, C. A. 1947. Fleas of the western United States. Iowa State College Press, Ames. 533 pp.

IGNOFFO, C. M. 1956. Notes on louse-host associations of the Great Salt Lake Desert, with keys to the lice. Great Basin Nat., 16: 9–17.

MILLER, G. S., JR., AND R. KELLOGG. 1955. List of North American Recent mammals. U.S. Nat. Mus., Bull. 205, xii + 954 pp.

RUSSELL, R. J. AND J. S. FINDLEY. 1954. Swimming ability of the grasshopper mouse. Jour. Mamm., 35: 118.

SPERRY, C. C. 1929. Life history and habits of grasshopper mice, genus *Onychomys*. Tech. Bull. 145, U.S. Dept. Agric.: 15–19.

———. 1941. Food habits of the coyote. U.S. Dept. Interior, Wildl. Res. Bull. 4, 70 pp.

SVIHLA, R. D. 1936. Breeding and young of the grasshopper mouse (*Onychomys leucogaster fuscogriseus*). Jour. Mamm., 17: 172–173.

[This work was supported by U.S. Army Chemical Corps contract, No. DA-18-064-CML-2639, with the University of Utah, and is contribution No. 30 from Ecological Research, Dugway, Utah.]

Ecological Research, Dugway, Utah. Received 17 September 1958.

GENERAL NOTES

MAMMALIAN REMAINS FROM AN INDIANA CAVE

During the course of exploration of a limestone cave in southern Indiana, a wood rat nest was discovered which contained the bones of at least 11 species of mammals. The remains of two of these, the wood rat and the spotted skunk, are of particular interest since they occur beyond the previously known ranges of the species. Three other species recovered from the nest (porcupine, elk and white-tailed deer) are now extinct in Indiana although known to have occurred within recent times. The nest was discovered in March 1958 by Jack Donahue of the Cave Research Association, University of Illinois.

The cave, known locally as Sullivan's Cave, is 1.5 miles west of Springville, Lawrence County, in the SE ¼, Sec. 20, T. 6 N, R. 2 W. It lies within the unglaciated or "knob" area of south-central Indiana, a region well known for its limestone sinks and caverns. The nest was discovered approximately 2,000 feet from the cave's entrance on a limestone shelf a few feet above the floor of a passageway. The shelf appears to represent the remnant of a former, and higher, cave floor. The rat probably had access to the outside through a fissure or crevice although none was observed in the vicinity. In addition to the mammalian remains listed below, the nest included nuts, shells of fresh-water snails, a considerable quantity of decayed vegetal matter, a few toad, snake and bird elements, and several unidentifiable bone fragments. Many of the latter had been extensively gnawed. The nest appeared to be relatively undisturbed although some of the debris, including a few bones, was found on the floor below. No other nests or bones were observed in the cave.

The positively identified mammals are as follows: *Didelphis marsupialis, Blarina brevicauda, Neotoma floridana, Erethizon dorsatum, Sylvilagus floridanus, Spilogale putorius, Procyon lotor, Urocyon cinereoargenteus, Odocoileus virginianus, Cervus canadensis* and *Myotis* sp.

Spilogale putorius is represented by a nearly complete left mandible including all teeth but the incisors. To our knowledge, this is the first indisputable evidence of the spotted skunk in Indiana. Lyon (Amer. Midl. Nat., 17: 1–384, 1936) summarized earlier unconfirmed reports of the species from Knox and Posey Counties in the lower Wabash Valley. *S. putorius* is known to occur in Tennessee and eastern Kentucky and on the west side of the Mississippi River in Missouri and Iowa (Van Gelder, Ph.D. dissertation, Univ. of Illinois). It is known only from archeological sites in Illinois (Parmalee and Hoffmeister, Jour. Mamm., 38: 261, 1957).

Neotoma floridana is represented in the cave collection by three mandibles, two maxillae and isolated teeth. This is only the third positive record of the species in Indiana and extends the known range approximately 50 miles to the north. A few specimens have been taken at Tobacco Landing, Harrison County, by Hickie and Harrison (Amer. Midl. Nat., 12: 169–174, 1930) and by Kirkpatrick and Conaway (*ibid.*, 39: 128–136, 1948); the latter also reported evidence of the animal in southern Orange County. Other unconfirmed reports of the wood rat in Indiana counties adjacent to the Ohio River are reviewed by Lyon (*op. cit.*).

The presence of the porcupine is indicated by two lower dentitions, and of the elk by a broken upper molar. Both are now extinct in Indiana but were widespread in the state in the previous century (Lyon, *op. cit.*). The white-tailed deer became extinct in this region, perhaps before 1900, but has been reintroduced. It is represented in our collection by the right M_2. The remaining species all occur in the vicinity today, as indicated by the recent survey of adjoining Jackson County by Mumford and Handley (Jour. Mamm., 37: 407–412, 1956).

The age of the nest is of interest but cannot, of course, be determined with certainty. Since nearly half the species recovered are now presumably absent from the area, it must be assumed that the mammalian fauna was somewhat different when "sampled" by the rat than it is today. However, since all these species may have been in the area in some

abundance as recently as a century or two ago, and since no definite Pleistocene indicators are present, an antiquity of at most a few hundred years seems most probable. It is possible that a C14 date may be obtained from the organic debris.—Robert S. Bader and John S. Hall, *Dept. of Zoology and Museum of Natural History, Univ. of Illinois, Urbana.* *Received 12 December 1958.*

LOCOMOTOR SPEEDS OF SOME LARGE NORTHERN MAMMALS

During the course of recent caribou investigations in northern Canada I had the opportunity of measuring the speed of unhurried locomotion of several large mammals in an undisturbed state. I am grateful to the Canadian Wildlife Service for the support which made these observations possible.

Ursus richardsoni, Barren-Ground Grizzly.—On 12 August 1958, at 62°24′N, 101°46′W, I watched three grizzlies moving south along the east bank of Thelon River. They moved at a fairly steady pace, pausing occasionally to forage briefly. During a one-hour period they moved a distance of 1 mile (measured from the map).

Canis lupus, Wolf.—On 12 August, while observing the grizzlies mentioned above, I noted a wolf trotting south along the east bank of Thelon River. He avoided the presence of the grizzlies, and trotted the same mile that they did in 15 minutes, or at a speed of 4 miles an hour.

Rangifer arcticus, Barren-Ground Caribou.—On 8 February 1958 I timed a doe and fawn caribou walking over hard, wind-packed snow on a frozen lake in northern Saskatchewan at 58°49′N, 105°52′W. The snow completely supported them. They walked a map-measured course of 1½ miles in 18 minutes, or at a speed of 5 miles an hour.

Ovibos moschatus, Musk Ox.—On 13 August 1958, at 62°24′N, 101°46′W, I kept a young-adult male musk ox under observation for most of the day. At one time he walked steadily along the sandy bank of Thelon River over a map-measured 1½ mile course in 30 minutes, or at a speed of 3 miles an hour.—William O. Pruitt, Jr., *Box 282, College, Alaska.* *Received 27 October 1958.*

NEWLY PROPOSED GENERA, 1952–56

The following comprises a list of generic and subgeneric names for living mammals proposed during the five years (1952–56) following the publication of *Index Generum Mammalium, 1904–51* (British Museum, 1953), and a name (incidentally an invalid one) unrecorded in that book.

BONOBOS Tratz & Heck, Säugetierk. Mitteil., 2: 97, 1954. *Pan satyrus paniscus* Schwarz. (S. of the upper Maringa R., 30 km. S. of Befolé, S. bank of the Congo, Belgian Congo. A native name. Primates, Pongidae.

CARPITALPA (sg. of *Chlorotalpa* Roberts) Lundholm, Ann. Transv. Mus., 22: 288, 1955. *Chlorotalpa* (*Carpitalpa*) *arendsi* Lundholm. (Pungwe Falls, S. Rhodesia, 2,000 m.) For Bernard Carp, leader of the Cape Town expedition to S. Rhodesia. Insectivora, Chrysochloridae.

CONGOSOREX (sg. of *Mysorex* Gray) Heim de Balsac & Lamotte, Mammalia, 20: 167, 1956. *Mysorex* (*Congosorex*) *polli* Heim de Balsac & Lamotte. Lubondaï, Kasaï, Belgian Congo.) Insectivora, Soricidae.

CYNOMACACA Khajuria, Rec. Ind. Mus., 50 (2): 303, 1953. *Papio ochreatus* Ogilby. (Celebes.) *κύων, κυνός*, dog + generic name. Primates, Cercopithecidae.

EUROSOREX (sg. of *Sorex* L.) Stroganov, Bull. Soc. Nat. Moscow, 57 (5): 22, 1953. *Sorex* (*Eurosorex*) *buchariensis* Ognev. (Valley of R. Davan-su, NW. Russian Pamir Mts.) *εὖρος*, S.E. Insectivora, Soricidae.

KILIMATALPA (sg. of *Chlorotalpa* Roberts) Lundholm, Ann. Transv. Mus. 22: 288, 1955. *Chrysochloris stuhlmanni* Matschie. (Karevia, Butago R., Ukongo, W. slopes of Mt.

Ruwenzori, Belgian Congo, 4,000 ft.) The name is evidently derived from (Mt.) Kilimanjaro, but the type did not come from there. Insectivora, Chrysochloridae.

LAGENODELPHIS Fraser, Sarawak Mus. Jour. 7 (8): 496, 1956. *Lagenodelphis hosei* Fraser. (Lutong R., Baram, Borneo.) λάγηνος, flagon + generic name, cp. *Lagenorhynchus* = bottle-nosed. Cetacea, Delphinidae.

LEONTIDEUS Cabrera, Neotropica, Notas zoo. sudamericanas, 2 (8): 52, 1956. *Simia rosalia* L. (Brazil.) λεοντιδεύς, young lion. Primates, Callithricidae (or Hapalidae).

MAYERMYS Laurie & Hill, List land mamm. New Guinea, Celebes, etc.: 133, 1954. *Mayermys ellermani* Laurie & Hill. (N. slopes Mt. Wilhelm, Bismarck range, NE. New Guinea, 8,000 ft.) For F. Shaw Mayer, collector for British Museum. Rodentia, Muridae (Hydromyinae).

MESOPOTAMOGALE Heim de Balsac, C. R. Acad. Sci. Paris, 242: 2,258, 1956. *Potamogale ruwenzorii* de Witte & Frechkop. (Mutsora, R. Talya, trib. R. Lume, W. flank Mt. Ruwenzori, Belgian Congo, 1,200 m.) μέζος, middle + generic name (ποταμός, river + γαλῆ, weasel), a medium-sized otter-shrew. Insectivora, Potamogalidae.

MICROPOTAMOGALE Heim de Balsac, C. R. Acad. Sci. Paris, 239: 102, 1954. *Micropotamogale lamottei* Heim de Balsac. (Ziéla, foot of Mt. Nimba, French Guinea, 550 m.) μικρός, small + generic name. Insectivora, Potamogalidae.

MINDANAOMYS Sanborn, Vidensk. Meddelelser Dansk Naturhist. Forening, 115: 287, 1953. *Mindanaomys salomonseni* Sanborn. (Mt. Katanglad, Bukidnow Prov., Mindanao, Philippines, 1,600 m.) Rodentia, Muridae.

NEOHYDROMYS Laurie, Bull. Brit. Mus. (N.H.), Zool., 1: 311, 1952. *Neohydromys fuscus* Laurie. (High N. slopes of Mt. Wilhelm, Bismarck range, NE. New Guinea, 9,000–10,000 ft.) νέος, new + generic name. Rodentia, Muridae (Hydromyinae).

PARACROCIDURA Heim de Balsac, Rev. Zoo. Bot. afr., 54: 137, 1956. *Paracrocidura schoutedeni* Heim de Balsac. (Tshimbulu [Dibaya], Lubondaï, 75 km. S. of Luluabourg, Kasaï, Belgian Congo.) παρά, near + generic name. Insectivora, Soricidae.

PARUROMYS (sg. of *Rattus* Fischer) Ellerman, in Laurie & Hill *ante*, 117, 1954. *Rattus dominator* Thomas. Mt. Masarang, N. Celebes, 2,000 ft.) παρά, near + generic name. Rodentia, Muridae.

RHINODORCAS (sg. of *Dorcas* Gray) von Boetticher, Z. Säugetierk., 17: 89, 1953. *Dorcas* (= *Gazella*) *spekei* Blyth. (Interior plateau of Somaliland.) ῥις, ῥινός, nose + δορκάς, gazelle. Artiodactyla, Bovidae (Antilopinae).

RUBRISCIURUS (sg. of *Callosciurus* Gray) Ellerman, in Laurie & Hill *ante*, 94, 1954. *Sciurus rubriventer* Forsten. (Minahasa, N. Celebes.) Lat. *ruber*, red + generic name. Rodentia, Sciuridae.

Omission.—"Oligotomus" Iredale *ex* MacGillivray, Austral. Zool., 9: 45, 1937. *Oligotomus australis* Iredale *ex* MacGillivray. (South Grafton, Clarence R., N.S.W.) ὀλιγός, few + τομός, cutting, on account of the "small number of cutters" [two upper incisors instead of four] (MacG.). Preoccupied by *Oligotomus* Cope, 1873, a fossil mammal, this name seems to have remained hidden in T. Iredale's publication of John MacGillivray's MS notes of 1866 until brought to light in Zoo. Rec. for 1956. Chiroptera, Vespertilionidae.—L. R. Conisbee, *1, Shaftesbury Ave., Bedford, England. Received 4 November 1958.*

LONGEVITY RECORDS FOR MAMMALS AT THE CHICAGO ZOOLOGICAL PARK

The following list of longevity records at the Chicago Zoological Park has been compiled from autopsy reports, from information supplied by Robert Bean, Director of the Park, and from files on small mammals kept by James E. Rowell. A survey of similar reports subsequent to Flower (Proc. Zool. Soc. London, 100: 145–234, 1931) indicates that most of the records below are probably maxima; three which are not have been marked with asterisks. Actual life spans of these animals are somewhat longer than the captivity intervals recorded, but in most cases there are insufficient data to make satisfactory projections.

	YRS.	MOS.		YRS.	MOS.
Ateles geoffroyi	18	—	*Jaculus jaculus*	7	0
Presbytis entellus	22	—	*Lagidium peruanum*	8	0
*Mandrillus sphinx**	24	—	*Ailuropoda melanoleuca*	15	—
Cercopithecus diana	19	—	*Felis concolor**	16	—
*Papio doguera**	30	—	*Babirussa alfurus*	21	—
Pongo pygmaeus	28	—	*Lama pacos*	20	—
Thryonomys swinderianus	4	2	*Kobus kob leucotis*	17	—
Dipodomys agilis	6	3	*Taurotragus oryx*	25	—
Neotoma lepida	5	7	*Strepsiceros strepsiceros*	23	—
Peromyscus polionotus	5	3	*Gorgon albojubatus*	20	—

GEORGE B. RABB, *Chicago Zoological Park, Brookfield, Illinois.* *Received 11 July 1958.*

SOME LONGEVITY RECORDS OF CAPTIVE MAMMALS

The following data on longevity of various species in captivity are submitted from records of the Zoological Society of San Diego:

1. Golden-headed saki, *Pithecia p. chrysocephala*, ♂—Received 29 Nov. 1946. Still living.
2. Hooded capuchin, *Cebus fatuellus paraguayensis*, ♂—Received 1927. Still living.
3. Kikuyu colobus, *Colobus polykomos kikuyuensis*, ♂—Received 1 Oct. 1940. Still living.
4. Proboscis monkey, *Nasalis lervatus*, ♂—Received 8 Jan. 1956. Died 18 Jan. 1960.
5. Giant tree squirrel, *Ratufa bicolor*, ♂—Received 1941. Died 20 June 1958.
6. Spectacled bear, *Tremarctos ornatus*, ♀ ♀—Received 11 March 1938. Died 16 July 1958 and 29 July 1959.
7. Northern elephant seal, *Mirounga angustirostris*, ♀—Received 25 Nov. 1953. Still living.

It is of interest to note that the hooded capuchin male listed above has sired 24 known offspring, including a set of twins. His latest offspring was born 30 May 1957. The most recent offspring of the Kikuyu colobus was born 24 July 1958.—GEORGE H. POURNELLE, *Zoological Society of San Diego.* *Received 13 October 1958.*

MAMMALIAN BODY TEMPERATURES

While collecting in southern California from 11–17 June 1955, the writer recorded a small number of mammalian body temperatures (cloacal). Temperatures were secured by means of a small, quick-registering, mercury, Schultheis thermometer. All animals were shot, generally after little or no chase, and it was possible to record the body temperature within 15 seconds.

The temperatures recorded for the following species are, respectively, the maximum, minimum and mean. The figure in parentheses indicates the number of animals collected: *Sylvilagus auduboni* (10), 41.4°, 39.6°, 40.1°; *Lepus californicus* (5), 40.8°, 38.5°, 39.9°; *Citellus beecheyi* (3), 39.8°, 39.1°, 39.5°; *Citellus leucurus* (8), 39.9°, 37.4°, 38.9°; *Neotoma lepida* (4), 38.2°, 37.1°, 37.7°; *Dipodomys deserti* (1), 39.3°; *Dipodomys merriami* (1), 39.6°C.—JOHN D. CUNNINGHAM, *Dept. of Education, Univ. of California, Los Angeles.* *Received 14 November 1958.*

LASIURUS FROM MISSOURI CAVES

Red bats, *Lasiurus borealis*, and hoary bats, *L. cinereus*, are considered tree bats—species which rarely use caves during any part of the year. Mention has been made of a lasiurine skull, skeleton or mummified carcass in a cave but seldom have more than a few individuals been found in any one location. As an exception to this, Hahn (Proc. Ind. Acad. Sci. for 1906, 142–144, 1907) reported finding about 200 red bat skulls in Donaldson's Cave,

near Mitchell, Indiana. Quay and Miller (Jour. Mamm., 36: 454–455, 1955) summarize these published reports and show that lasiurine bats have been taken from ten mines or caves in seven states (Indiana, Kentucky, Missouri, New York, New Mexico, Tennessee and Utah). An additional record is that of Beer (Jour. Mamm., 35: 116, 1954) who described finding a mummified hoary bat on the floor of a man-made cave in St. Paul, Minnesota, during the winter of 1950.

A thorough search of 109 caves in Missouri from July 1954 to November 1958 has revealed lasiurine remains or live specimens in 13 (Table 1). Ten of the 13 contained remains similar to those reported in the literature; a skull, skeleton or mummified carcass usually well within the cave. One of the ten caves had three living male red bats on 18 July 1954, but none has been found there since.

TABLE 1.—*Total number of lasiurine bats from Missouri caves, 1954–1958*

DATE	CAVE	COUNTY	NUMBER OF BATS COLLECTED		ZONE IN CAVE
			L. borealis	*L. cinereus*	
July 1954	Tunnel	Pulaski	3 ♂♂, alive		by entrance
July 1954 to present	Bat	Pulaski	46 alive/fresh dead 60 skulls/skel.	2 ♂♂, alive 5 skulls/skel.	far inside
Sept. 1954	Spring	Pulaski	3 skulls		far inside
Oct. 1954	Bruce	Pulaski	3 skulls		far inside
Oct. 1954 to present	Piquet	Pulaski	77 alive/fresh dead 190 skulls/skel.	1 ♂, dead 8 skulls/skel.	far inside
Feb. 1955	Freeman	Pulaski	1 mummified		by entrance
Aug. 1955 to present	Inca	Pulaski	142 alive/fresh dead 1,100 skulls/skel.	3 ♂♂, 1 ♀ alive. 2 skulls	far inside
April 1957	Joel	Camden	1 skull		far inside
Oct. 1957	Carrell	Camden	1 skull		far inside
Oct. 1957	Hunter's	Boone	1 mummified		by entrance
Nov. 1957	Unnamed	Boone	1 skull		far inside
April 1958	Powder Mill	Shannon	5 skulls	1 skull	far inside
Aug. 1958	Bat	Laclede	1 skeleton		far inside

With respect to use by bats, three Missouri caves in which bats were found differed from the other ten in that large numbers of both live and dead lasiurines were found in them.

These caves were located in Pulaski County within a radius of 10 miles. The living bats were observed in various physical conditions; some were extremely weak and emaciated, too feeble to crawl or fly. They were found on the floor or were attached to the ceiling. Others were taken from the ceilings and walls in a torpid condition but were capable of normal activity once aroused, and I have come upon red and hoary bats in caves flying too swiftly to permit capture by a hand-net. Dead red and hoary bats also were found in all stages of decomposition. From some it was possible to prepare study skins, while others had decomposed beyond recognition of sex, particularly so if small beetles of the genus *Ptomaphagus* were present. Some skulls and skeletons were well cleaned and relatively strong, but others were too fragile to gather.

Although the red bat was the predominant one of this genus in the caves, I have found approximately one hoary bat to 72 red ones. Among red bats, males exceeded females both in number of live and dead animals (Table 2) and juveniles were more common than

adults after the last of July. It was possible to separate juveniles from adults until early October by the ossification of the epiphyseal region of the phalanges.

The bats tended to congregate and die within specific areas, usually at the far end of an inner passage. I have watched red and hoary bats flying about seeking a place to hang on the walls or ceilings, but they had difficulty finding footing on anything except rough rock. This may be one reason why lasiurines are most commonly found in and around "breakdown" rooms, i.e., rooms formed by failure of the ceiling.

It appears that the bats do not leave once they enter a cave. Not only do the vast number of skulls, skeletons and bones in flowstone terraces suggest this, but wing-banding with U.S. Fish and Wildlife Service No. 0 bands substantiates it. Of 15 male and 10 female red bats banded between 1954 and 1958 and released at the place of capture within the cave, seven males and four females (44 per cent) were found dead near the spot where liberated, usually during the next visit to the caves. Banding has not demonstrated any movement of these bats from one cave to another.

TABLE 2.—*1957–1958 records of live and fresh-dead L. borealis in Bat, Inca and Piquet Caves, Pulaski Co., Missouri*

MONTH	1957					1958				
	No. obs.	♂	♀	Sex ?	Total	No. obs.	♂	♀	Sex ?	Total
April	1	0	0	0	0	4	2	3	0	5
May	3	0	0	0	0	2	3	0	0	3
June	9	16	2	0	18	8	12	0	2	14
July	5	11	0	0	11	4	6	1	2	9
Aug.	10	35	23	9	67	10	17	9	1	27
Sept.	5	2	0	8	10	2	12	6	4	22
Oct.	6	11	0	8	19	3	6	1	1	8
Nov.	8	9	0	1	10	2	3	0	0	3
TOTAL	47	84	25	26	135	35	61	20	10	91

Why large numbers of red and hoary bats should enter these three particular caves and not others in south-central Missouri, and die in certain areas deep within the caves, remains obscure. An examination of the physical structure of the caves gives no clue; all are large extensive caves and have streams emerging from entrances which are at least 40 ft. in diameter. All contain summer nursery colonies of *Myotis grisescens* as well as hibernating groups of *M. sodalis* in winter. The climate is constant in the rooms where the lasiurines die; temperatures near the ceiling average 58.7°F. (57.5–61.0°) and relative humidities at these same points average 93 per cent (89–97). In the same county there are at least 150 caves, 15 of which are of comparable size and contain similar *Myotis* populations, yet they harbor no concentrations of lasiurines. Nor does it seem that outside temperatures and weather conditions are responsible, since the bats have been taken in the caves during the spring, summer and fall during periods of wetness as well as extreme drought. Four red bats from the caves were examined for rabies by the Fifth Army Medical Laboratory in St. Louis in 1954, and eight more from the same caves were tested in 1957 for this disease by mouse innoculation in the veterinary laboratory at the University of Illinois, in connection with the sylvan rabies study of the Illinois Natural History Survey. All tests proved negative.

This phenomenon has occurred for a number of years judging from the great amount of skeletal material accumulated in depressions, under rocks and incorporated in the flowstone terraces. Older residents of the area have mentioned that, in their youth, they visited rooms of these caves which they called the "bat graveyards," and it was the odor of decaying bats which first led Edward C. Cannard to the death rooms in Inca Cave in 1955 (*in litt.*). *M. lucifugus, M. sodalis, M. grisescens, Pipistrellus subflavus* and *Eptesicus*

fuscus use these caves and are quite often found in the same rooms with the lasiurines, yet rarely are any of these true cave bats found dead in the caves.

I am indebted to Clinton H. Conaway and William H. Elder, University of Missouri, and Carl O. Mohr and Thomas G. Scott, Illinois Natural History Survey, for their helpful editorial suggestions. Edward C. Cannard, State College, Pennsylvania, Robert E. Lewis, University of Illinois, Michael Hull, Robert Wilkinson, Jr., and David Easterla, University of Missouri, gave invaluable aid in collecting in the caves. Eugene Wood, University of Missouri, kindly identified the beetles, *Ptomaphagus*.

Part of these observations were assisted financially by the Missouri Cooperative Wildlife Research Unit, the Section of Wildlife Research of the Illinois Natural History Survey (National Institutes of Health Grant for a sylvan rabies program, project E-1349), and the National Science Foundation, Grant No. 4386.—Richard F. Myers, *Dept. of Zoology, Univ. of Missouri, Columbia.* *Received 23 December 1958.*

A FREE-TAILED BAT FOUND IN OHIO

A single male *Tadarida brasiliensis cynocephala* (LeConte) was collected on 31 July 1958 in a barn 10 miles northwest of Portsmouth in Scioto County, Ohio. This is the northernmost known extent of its range. The bat was collected during one of 10 routine checks for banded bats in this barn during the summer. This collection was the only one in which bats of any species except *Eptesicus fuscus fuscus* were found. During this collection, 41 big brown bats, *Eptesicus fuscus fuscus*, were caught (16 adult females, 11 juvenile females and 14 juvenile males). The *Tadarida* was not in close association with the *Eptesicus* but in a separate crack about 10 feet away. Its measurements (in mm.) were as follows: Total length, 103; tail, 43; foot, 11; ear, 20; tragus, 6; greatest length of skull, 29.

We appreciate the cooperation of D. F. Hoffmesister of the University of Illinois in identification.—Elizabeth Smith and Woodrow Goodpaster, *Dept. of Zoology, Pennsylvania State Univ., Erie.* *Received 21 November 1958.*

FREQUENCY AND PLACEMENT OF WHITE FUR ON FREE-TAILED BATS

In south-central Texas during 1957, examination was made of 47,409 Mexican free-tailed bats to determine the frequency and placement of white or unpigmented fur. Random samples of bats were taken at four different caves from March through August of that year. When a bat was found with white fur, the approximate size and position of the spot were recorded as well as the sex and tooth wear of the animal. Some confusion resulted from attempts to catalog white spots on the ventral surface of the body because of the much lighter buff color of the venter and the light color of throat hair that was typical of many specimens. Thus, attention was mainly directed to white fur appearing on the dorsum.

White fur on the back occurred as patches in a variety of shapes with the width varying from ⅛ inch to more than an inch. White patches were recorded as occurring on the head, neck, upper back, middle back or rump regions. Some specimens had spots in more than one region, either because of an overlap of a spot from one region to the next (uncommon) or because two or more distinct spots existed on different parts of the body. Of the 149 bats found to have white fur, 20 had spots in more than one region.

Following are the frequencies at which white fur patches were found within each region: head, 43; neck, 10; upper back, 68; middle back, 27; rump, 10. Clearly, the upper part of the back had more white fur on it than any other part of the dorsum. Most of these spots were located over the scapulae. The shoulder spots occurred singly on either the right or left side, with equal frequency, or were on both shoulders. White fur on one shoulder was found four times more often than spotting on both (12 specimens). In addition, six bats were flecked with small, distinct, white spots over most of the body and five others had outstanding marks on the abdomen.

Table 1 shows the numbers of adult bats examined and the percentage of animals having white patches of fur. Subdivisions of the data were made on the basis of sex and tooth wear (or relative age) of the bat and the cave at which it was taken. It is apparent that there was little difference among caves. About one bat out of 3,000 to 4,000 had some white fur. The percentage of animals with white fur patches increased with increasing tooth wear or relative age of the bats. Even the young of the year were consistent with this pattern. Only one out of 1,960 juvenile females (.051 per cent) and one out of 1,848 juvenile males (.054 per cent) had white fur. The total percentage of adult females with white fur patches is larger than that for adult males. This is in spite of the fact that when the sexes are compared, age class to age class, the males indicate more white fur. The reason for this difference between totals is that 87 per cent of the males examined were young (with little white fur) while only 44 per cent of the females were of this class.

TABLE 1.—*Percentages of adult free-tailed bats in Texas caves with aberrant white fur*

	FEMALES			MALES			CAVE TOTALS
	Young	Intermediate	Old	Young	Intermediate	Old	
			Ney Cave				
No. examined	5,080	4,445	2,106	1,647	166	24	13,468
% with white fur	0.079	0.36	0.85	0.24	0	0	0.31
			Bracken Cave				
No. examined	5,016	3,574	1,223	1,293	165	11	11,283
% with white fur	0.14	0.50	0.57	0.23	0.61	0	0.32
			Davis Cave				
No. examined	3,003	3,397	1,399	1,315	158	31	9,303
% with white fur	0.23	0.50	0.43	0.15	1.30	0	0.36
			James River Cave				
No. examined	3,243	3,122	1,152	1,675	317	38	9,547
% with white fur	0.15	0.64	0.61	0.12	0.63	2.6	0.39
Totals	16,342	14,538	5,880	5,930	806	104	43,601
% with white fur	0.14	0.49	0.65	0.18	0.62	0.96	0.34
		0.36% ♀♀			0.25% ♂♂		

Uniformity among caves is understandable considering that a portion of the population of each cave readily shifts about and, as demonstrated by our banding efforts, often turns up in other caves. If the frequency of the occurrence of white patches is shown to be the same in other parts of the range of the Mexican free-tailed bat and if this phenomenon is of genetic origin, then it supports the idea of homogeneity of the species suggested by the banding data. No changes were noted in the frequency of occurrence of white coloration with the passage of time.

Two likely explanations for the increase of white fur with age are that a phenomenon similar to the graying of human hair occurs as the bats grow older, or that as injuries occur to some of these animals the hair growing back over the scar tissue is white in color. This does not imply that all white fur of bats originates in this way, but that some of the increase of white spotting with age may be accounted for in this manner.

Although no albinism, involving lack of pigment in the fur, skin and irises of the eyes, was noted during the 1957 study, in 1959 an albino free-tailed bat was obtained. The animal was a juvenile female taken in James River Cave, Mason County, Texas on 14 July. Although several bats with only white fur had previously been taken in 1958, these animals had the normally pigmented skin and eyes.

There appears to be no record of an albino bat of the genus *Tadarida* up to the time of Setzer's review in 1950 (Jour. Mamm., 31: 350). Glass (Amer. Midl. Nat., 52: 400–402,

1954), however, states that the Mexican free-tailed bat can be added to the list on the basis of the numerous examples of "albinism" that he reports. If we accept as a definition of albinism the absence of pigment in the skin and iris of the eye as well as in the hair, then Glass's specimens cannot be regarded as albinistic but rather as occurrences of white fur, as are the cases noted above. Furthermore, the "chin-whiskered" specimens that Glass reports are high in prevalence in the Texas caves, but should not be considered examples of albinism. Many bats of this species have lighter colored hairs around the chin and neck and there are all degrees of development of chin whiskers.

This work was supported by grant E1040 from the National Institutes of Health. Dr. William B. Davis rendered valuable assistance during the preparation of the manuscript. —Clyde F. Herreid II and Richard B. Davis, *School of Hygiene and Public Health, Baltimore 5, Maryland.* *Received 10 September 1958.*

ALBINISM IN *TADARIDA*

In 1952, Glass (Amer. Midl. Nat., 52: 400) reported on several *Tadarida brasiliensis mexicana* (Saussure) which had scattered patches of colorless hair. Since 1952 two specimens have been collected which exhibit the ultimate in this type of albinism. Both of these specimens (OSU 2409 and 2410) completely lack pigment in the body hair. The hair of these bats is chalky white on dorsum and venter, contrasting sharply with the dark, normally pigmented skin. These bats were taken in the Woodward and Major County colonies mentioned by Glass.

A true albino *Tadarida* was secured by the writer on 28 August 1957 in Merrihew Cave (Sec. 17, T. 29 N, R. 17 W), Woods County, Oklahoma. This specimen (OSU 3283) is a male which lacks pigmentation in hair and skin. The iris of this bat was pink in life. The epiphyseal method of aging indicates that it was born in the summer of 1957 and had not made its first migratory flight.

A second albino *Tadarida* was collected in Selman's Cave (Sec. 22, T. 26 N, R. 19 W), Woodward County, Oklahoma, on 24 July 1958. This bat (OSU 3637) is a female born during the summer of 1958. In addition to these complete albinos there is another young *Tadarida*, in the same collection, lacking pigment in hair and skin but which, in life, had normally pigmented eyes. This bat was collected by Glass at Reed Cave (Sec. 27, T. 5 N, R. 24 W), Greer County, Oklahoma, on 30 July 1958.

Setzer (Jour. Mamm., 31: 350, 1950) listed the genera of bats in which albinism is known to occur but did not mention *Tadarida*. Our specimens apparently are the first records of true albinos in this genus.

This is Contribution No. 279, Department of Zoology, Oklahoma State University. Investigation supported (in part) by Research Grant E-819, from the National Institute of Allergy and Infectious Diseases, U.S. Public Health Service.—Clarence J. McCoy, Jr., *Oklahoma State Univ., Stillwater.* *Received 15 December 1958.*

UNUSUAL COTTONTAIL LITTER

On 26 April 1958, Robert H. Perkins of Lafayette, Indiana exposed a cottontail, *Sylvilagus floridanus mearnsi*, nest and litter in the side of a 2-foot-high pile of topsoil as he was moving the earth with a tractor loader. Since nest cavity and site were destroyed, the young (numbering 12 in all) were gathered and hand-fed until deaths 4–13 days later claimed the entire litter. Approximately 65 hours after rescue (and after several feedings) individual nestling weights in grams were: 29.3, 31.6, 33.0, 35.7, 36.0, 37.5, 41.0, 42.0, 42.4, 48.5, 50.0, 55.8.

A survey of the literature reveals but one record of a single litter of cottontails numbering more than eight rabbits. Hendrickson (Amer. Forester, 21: 59–74, 1943) reported nine in one nest presumably belonging to one mother. He also found litters of 11 and 12, each

of which clearly contained two sizes, indicating young of two females using common nests. Whether the present litter was offspring of one or more does, 12 cottontails in one nest seems of sufficient rarity to warrant this record.

As another point of interest, the nest material was mainly alfalfa stems. The nearest supply of alfalfa was 50 yards from the nest site in the earth pile, indicating the adult carried the material that distance. The transport of nesting materials by *Syvilagus* from places distant from the nest is known but infrequently recorded (Trippensee, Trans. N. A. Wildl. Conf., 1936: 344–352; Fitch, Calif. Fish and Game, 33: 159–184, 1947).—CHARLES M. KIRKPATRICK, *Purdue Univ. Agr. Exp. Sta., Lafayette, Indiana. Received 3 November 1958.*

TREE CLIMBING BY MOUNTAIN BEAVERS

Late in October 1957, a fresh pile of twigs of white fir (*Abies concolor*) and lodgepole pine (*Pinus contorta*) was found to comprise the entire cache of a colony of mountain beavers, *Aplodontia rufa californica*, near Huntington Lake, California. This recalled a statement by Seton (LIVES OF GAME ANIMALS, 1929) to the effect that hunters say the mountain beaver can and does climb trees, but that naturalists claim it can no more climb trees than can a mole or a muskrat.

Scheffer (Farmers' Bull. 1598, U.S. Dept. Agric., 1929) says there is no evidence that mountain beavers in the Northwest can climb trees, although they prune low shrubs.

Grinnell and Storer (ANIMAL LIFE IN THE YOSEMITE, 1924) state the animal is not known to climb. It has been known for some time that mountain beavers do trim young forest saplings so severely as to kill them (Hamilton, AMERICAN MAMMALS, 1939), but most workers supposed the animals did so from the surface of deep frozen snow.

At the site of the Huntington Lake colony, some of the young firs were not only trimmed and topped, but were completely denuded of bark. This damage is known to have been done during the deep snows which also allow the animals to burrow down along the trunks from the surface. Because only a few inches of snow had fallen in the fall of 1957, it was obvious the fresh evergreen twigs in the cache could not have been gleaned with the help of snow.

An investigation revealed that the twigs had been pruned from trees 12–15 feet tall.

In June 1959, a steel pen 24 inches high was constructed, enclosing 110 square feet of natural vegetation used as food by mountain beavers. It included four lodgepole pines. The pen was built about 300 yards below the site of the colony on the same seepage. Two underground nest boxes were constructed outside the pen but were connected with it by underground 4-foot lengths of 4-inch tile.

An adult female mountain beaver weighing 1,064 grams and another female weighing 652 grams were live-trapped and released in the pen on 6 August. Both remained there for three weeks, when the larger animal was marked and released; the smaller one was kept three weeks longer for further study.

During the first 10 days there were sufficient food plants growing in the pen to supply their needs. Ample natural food was supplied daily thereafter. However, every night and sometimes even during the day, some of the lodgepole pine twigs were cut, and the needles were eaten.

Climbing by these captive mountain beavers was observed and photographed several times. Climbing was accomplished by advancing one foreleg, then the opposite hind leg, in succession. The forefeet actually grasp the small branches and the hind feet are simply placed on them (Plate I). Where branches are lacking, the animal applies the claws of both feet to the bark of the trunk in climbing. The smooth bark of the small white firs at the site of the colony shows unmistakable claw marks 12 feet from the ground.

Twigs up to 30 inches long and ½ inch in diameter are readily cut off in a few seconds from 2–10 inches out from the trunk. One tree, 12 inches in diameter, had three twigs cut off

5 feet from the trunk and about 6 feet from the ground; however, these cuts were not fresh and they could have been made during the past winter while the snow was deep and frozen. Two of the lodgepole pines which showed some pruning at the site of the colony were about 12 inches in diameter. One of them had twigs cut as high as 20 feet from the ground.

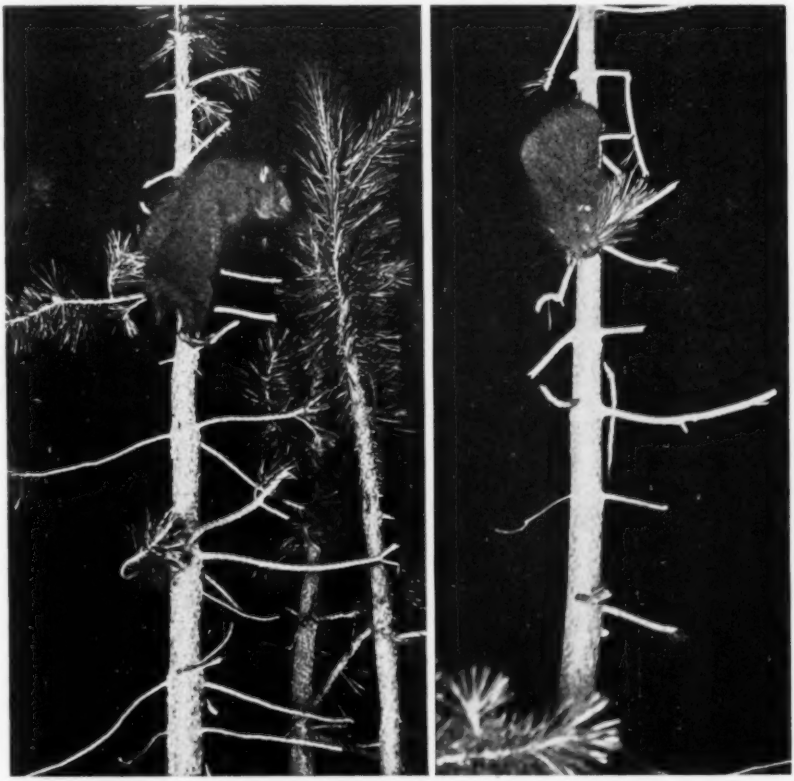


PLATE I

LEFT: A mountain beaver climbing a lodgepole pine. RIGHT: The same animal descending a tree with a twig; notice the results of the pruning.

Sometimes, after a twig was cut off, it was allowed to fall to the ground, but more often it was carried down in the animal's mouth as it descended the trunk head first (Plate I). The descent was made more slowly than the ascent, as the branches, or their remaining stubs, were again utilized to the utmost as rungs of a ladder. The forefeet grasped them tightly as the hind feet extended around the trunk as far as possible to provide the "brake."

After six weeks, the four lodgepole pines in the pen were completely pruned of lateral branches and even the terminal buds were cut off. Mountain beavers can and do climb trees, at least up to 20 feet from the ground.—LLOYD G. INGLES, *Fresno State College, Fresno, California.* *Received 7 October 1958.*

CAPTIVE COLONIES OF *TAMIAS STRIATUS*

This paper records observations from June 1955 to June 1957, on groups of *Tamias striatus* in an outdoor cage in St. Louis, Missouri. Daily notes were taken and each June the burrow systems were carefully excavated for study. The authors previously investigated natural burrow systems in Wisconsin (Jour. Mamm., 37: 23–31, 1956) and summarized other field observations on this chipmunk (*Ibid.*, 38: 192–196, 1957). The only previous investigation in an outdoor cage of the type used here was that of Engels (Ecology, 32: 549–555, 1951), but he did not describe the nature of the burrows.

Methods.—The wire-mesh cage (Plate I, *above*), 9½ × 5½ × 3 feet above ground, extended 3 feet below the surface where it terminated in cinders. There were no escapes. To locate points within the cage the area was designated by the numbers 1–19 along the sides and the letters *A–K* along the ends. A box with ten compartments with wire-mesh rear walls and 2 × 2 inch openings to the cage was fastened to the south wall. For 1956–1957, an artificial burrow was prepared with a 2-inch pipe as its entrance leading to a wire-masonite cage 12 × 12 × 8 inches, 24 inches below ground. The chamber was located at *J*-2, the surface entrance at *F*-1.

Purina laboratory chow, in a wire feeder, and water were available at all times, even during freezing weather when fresh water was added daily. Loose chow and fresh foods as well as abundant nesting material were frequently made available. At the beginning of each experiment, on 16 June 1955 and on 25 September 1956, eight Wisconsin animals in their second year of captivity were marked and released into the cage. On 1 June 1956, and on 7 June 1957, the survivors were captured and their burrow systems studied in the manner described by us previously.

Observations.—The captive animals never became tame, and although several took food from the hand, they could never be touched or handled. Most retreated to their burrows when approached. There was no serious fighting among the animals. The suspended compartments were used promptly by most. Food was taken to these sections before the burrows were established and at intervals thereafter. The artificial burrow was also promptly used, once by six animals.

In 1955–1956, there were erratic attempts at burrowing within a few minutes after release. Moderate burrowing began at the end of the first week and continued until the end of October. Burrow openings were mostly around the edge of the cage at *A*-1 to 10, *J*-1 to 10, and *F*-16. There were few signs of activity in the central areas. Later evidence indicated that much more soil was removed during this period than was apparent above ground, but it was not noticed because of the careful manner in which the chipmunk spreads the excavated soil.

Cold weather in early November occasioned more vigorous activity, especially at *B*-2 and *K*-2. In late November the principal entrances were opened and closed in an irregular pattern. Food and many leaves were taken below ground, and some food was taken to the compartments. No animals were seen above ground from 18 December until 2 May. All entrances were closed during this period of inactivity.

On 2 May entrances at *J*-16 and *J*-2 were opened and food was taken below for the first time in nearly five months. During the rest of May, evidence of activity was seen almost daily. On 27 May a healthy male and female were trapped, the remaining six animals having died during the winter. The burrow system then excavated is shown in Plate I, *below*.

The model shows that considerable portions of the tunnels were plugged. The two surviving animals were utilizing only a small portion of the underground network at the time of capture; several inches of soil blocked the passageway to other tunnels and chambers. The greatest depth of the systems was 3 feet; the large chambers, however, were only 2 feet below the surface. The entrance to one system, located in the foreground of Plate I, *below*, was apparently shut off by a chipmunk from the surface. It had only one occupant, a dead chipmunk packed in the soil of a side pocket. Considering the nature of this side

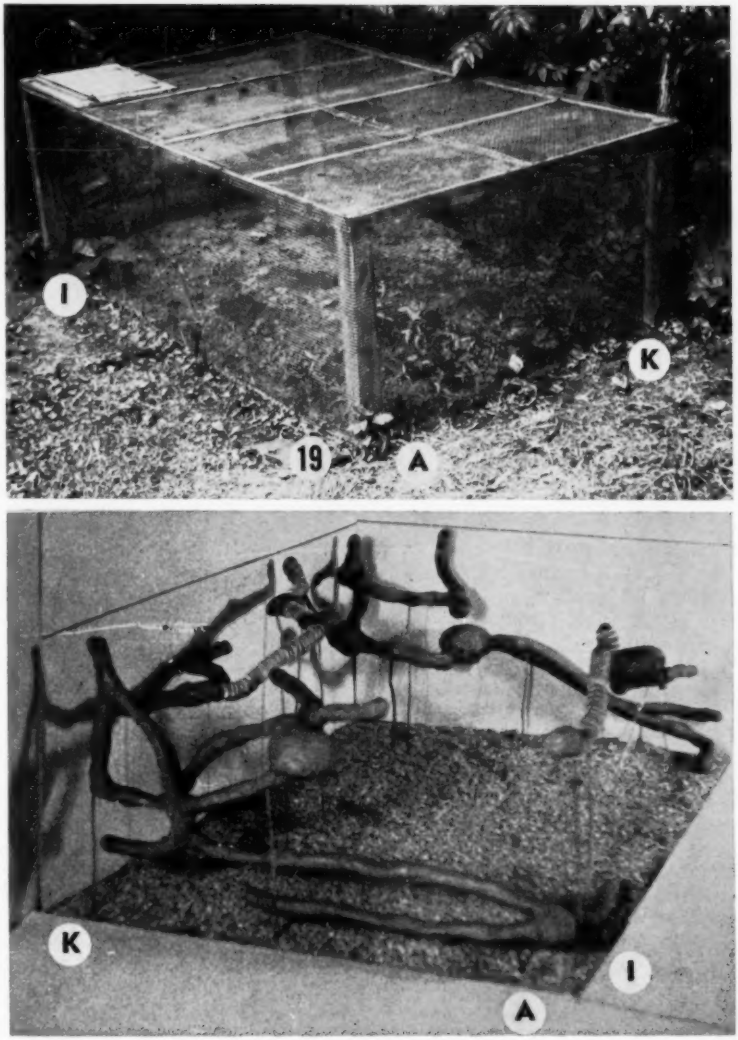


PLATE I

ABOVE: The outdoor cage. Elevated compartments appear at the south wall. The letters *A* and *K* and the numerals 1 and 19 indicate the plan for locating points within the cage.

BELOW: Clay model of the systems of the outdoor cage during 1955–1956. The upper line indicates the surface of the soil, and sawdust marks the lower limits of the cage. Cross-hatching in certain areas indicates that these sections were plugged. *A*-1 locates the southeast corner.

pocket and the neighboring parts of the system, it seems likely that another animal disposed of the carcass in this manner, first packing the body in a side chamber and then sealing off the entire system from the surface. No other animals were found entombed in this manner, although dead animals were occasionally found on the surface.

The systems contained three large nests. Purina chow was stored in small amounts, but did not preserve well. Some nuts were stored, even in areas of the systems which were sealed off.

In 1956-1957, there was little burrowing activity until 25 November. From then until the end of December there was extensive digging and food storing. January 15 marked the last activity at the entrance of the artificial burrow. There was moderate burrowing activity throughout the winter with the exception of 23 January to 5 February. Entrances were frequently, apparently irregularly, opened and closed. They were closed both from above and below the surface; sometimes they were opened or closed for only a few hours' duration. Detailed records of these soil movements present a baffling display of activity, and it is difficult to convey by generalizations an adequate understanding of these strange patterns.

On 3 June, two survivors of the experiment, one male and one female, were trapped and the burrow systems were excavated. Because of the collapse of certain sections from heavy rains, it was not possible to map these systems completely. In general, they were similar to the complex network of 1955–1956. It appeared that at one time the entire network had been connected. The amount of storage was greater than in the first year. Seeds and corn were stored far in excess of possible use during the winter. Sections of tunnels and chambers were literally stuffed with food so that passageways were tightly blocked. The artificial burrow had been filled almost to its roof with leaves and food; the entrance was solidly plugged with soil, and a dead chipmunk was inside.

Discussion.—Most of the data obtained from the study of natural burrows were confirmed in this cage experiment. The erratic opening and closing of entrances was observed by us for the first time. Plugged work-holes, described in the earlier paper, may serve a function that is easily understood, namely, as an aid in concealing entrances to a system. The opening and closing of entrances observed in the cage offer a more mysterious problem.

The extensive refilling of tunnels was also surprising. Some activity of this nature had been observed in the Wisconsin wilds, but never to this extent. Perhaps it was just missed during the field work or perhaps the restricted area of the cage exaggerated the activity. It could also be a segregation mechanism to isolate certain portions of a system if, for some reason, animals wished to live separately. Such a situation would arise much less frequently in nature. Of course, like so many natural history phenomena, the activity could be a behavior pattern which is inexplicable in terms of our anthropomorphic reasoning, and thus demands a special study.

Burrowing throughout the winter during 1956–57 was unexpected. Since each animal had been in captivity for at least a year prior to its use in the cage experiment, any "internal cycle" relating to burrowing habits may have been disrupted. Yet it seems significant that cold weather provoked more serious activity. Also of interest is the fact that the air temperatures during October, November and December of 1956 averaged 5.0°F. higher than the year preceding.

The inactivity from 18 December 1955 to 2 May 1956 is perhaps related to hibernation; laboratory experience, however, indicated that great caution must be employed in interpreting hibernation behavior in *Tamias* (Panuska, Jour. Mamm., 40: 554–566, 1959). The activity of the 1956–1957 winter will suffice to show the varied pattern of winter behavior that apparently is characteristic of this species.—Joseph A. Panuska, *Woodstock College, Woodstock, Maryland,* and Nelson J. Wade, *Dept. of Biology, St. Louis Univ., St. Louis, Missouri.* *Received 22 September 1958.*

POSSIBLE HIMALAYAN COLOR PATTERN IN *EUTAMIAS*

A specimen of the gray-necked chipmunk, *Eutamias cinereicollis* (Allen), possibly of Himalayan color pattern, was shot among the rocks along state road 61 in the Black Range, 15 miles east and 28 miles north of Silver City, Grant County, New Mexico, on 28 August 1958. The predominant vegetation in the immediate area consisted of yellow pine (*Pinus ponderosa*) and Gambel oak (*Quercus gambelii*). The chipmunk is a subadult female, Catalog No. 5395 UNM, preserved in the University of New Mexico Collection of Vertebrates.

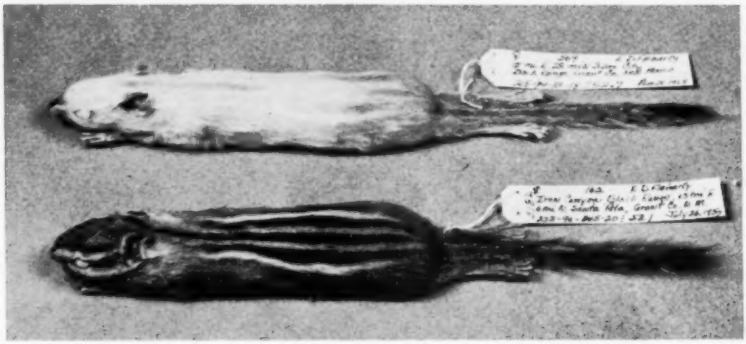


PLATE I

ABOVE: A possible Himalayan *Eutamias cinereicollis*. BELOW: A normal *Eutamias cinereicollis* from the same general area. Photo courtesy Richard Forbes.

In this specimen (Plate I) the mid-dorsal dark stripe is light grayish-brown and extends from mid-body to between the ears. The other dark stripes are gray posteriorly and become whitish-gray anteriorly, while the dorsal light stripes are light gray on the rump becoming white anteriorly. The hind legs and the dorsal sides of the hind feet are gray. The dorsal surface of the tail is grayish-brown basally becoming gray posteriorly and finally black at the tip. Ventrally the tail is whitish-gray throughout its length. The hair on the tail is tipped with white. The ventral body surface, the face, and the dorsal side of the head are white in contrast to the ears which are grayish-black and the dorsal side of the snout which is black. The eyes of the freshly killed animal were pink. According to Dunn (Jour. Mamm., 2: 125–140, 1921) this type of pattern is of the Himalayan type of albinism which has been demonstrated in other mammals, such as the guinea pig and the domestic rabbit. Albinism has been reported twice for the eastern chipmunk (Jour. Mamm., 2: 130, 1921; 35: 585–586, 1954), but to our knowledge there has been no reported record of a true ablino or Himalayan chipmunk of the genus *Eutamias*.—EUGENE D. FLEHARTY AND CLYDE J. JONES, *Dept. of Biology, Univ. of New Mexico, Albuquerque.* *Received 13 October 1958.*

TREE-CACHING BEHAVIOR IN THE GRAY SQUIRREL

A commonly observed autumnal activity of the gray squirrel, *Sciurus carolinensis leucotis*, in southern Wisconsin is that of food caching. Ordinarily the food, such as acorns (*Quercus* spp.), butternuts (*Juglans cinerea*), hickory (*Carya ovatus*) and black walnuts (*Juglans nigra*), is cached in the debris covering the forest floor. Less frequently hollow tree trunks and fallen logs are used. The result of these types of food caching is that the food is nearly always concealed from view. A seemingly rare caching behavior displayed by the gray squirrel is that of storing food in the aerial branches of trees and shrubs. The obvious difference between this and other types of caching is that the food is in no way concealed.

This "aerial caching" behavior has been observed rather frequently during the past four years in the University of Wisconsin Arboretum at Madison, Wisconsin. There has not yet been any report of this behavior observed on a large scale.

The caching of food in trees and shrubs has been especially frequent in that part of the University Arboretum where a well-developed oak wood lies contiguous to an artificially established pine forest. A large number of butternut trees are in that portion of the oak wood immediately adjacent to the pine forest. Butternuts have provided the bulk of the food found aerially cached, and white pine (*Pinus strobus*) and red pine (*P. resinosa*) saplings have provided most of the caching sites. The butternuts are usually cached in the uppermost whorl of the pine saplings, 2 to 4 meters above the ground. The upper whorls are most frequently used because the lateral branches composing them are rather close together and form natural pockets. Acorns and hickory nuts are not large enough to be successfully lodged in the pine saplings. Black walnuts occasionally are cached here, but the number of walnut trees is small and they are located at some distance from the pine forest.

A check was made in the fall and winter of 1957–58 to determine the future of the aerially cached butternuts. Sixty-five pines possessing cached butternuts were tagged in the late fall and periodic checks were made of the recovery of these nuts. It was surprising to find that the squirrels had recovered 69 per cent of the butternuts before 1 January 1958, well before the worst part of the winter season. By 1 March 1958, all but one of the butternuts had been recovered, resulting in a 99 per cent recovery rate. Butternuts cached in the pine saplings cannot accidentally fall from the pines under normal conditions. It was usually necessary to shake the pines vigorously in order to dislodge the nuts for examination; occasionally even this shaking failed.

It is not well understood why the gray squirrels in this area display tree-caching behavior to such a high degree, since it is apparently a rare activity under usual circumstances. The occurrence of butternut trees adjacent to pines is rather a rare situation in the range of the gray squirrel; the situation in the University Arboretum is completely artificial. Some caching is done in low shrubs, but these cached nuts comprise less than 1 per cent of the total aerially cached. It is entirely possible that aerial caching is a well-developed behavior in the gray squirrel, but is expressed only in particular situations such as that described here.—James R. Habeck, *Botany Dept., Univ. of Wisconsin, Madison 6.* *Received 14 November 1958.*

[Contribution from the University of Wisconsin Arboretum. Journal Paper No. 41.]

DISTRIBUTION AND HABITS OF KANGAROO RATS AT MORRO BAY

An isolated subspecies of Heermann's Kangaroo Rat, *Dipodomys heermanni morroensis*, is known only from the south side of Morro Bay, San Luis Obispo County, California. Grinnell (Univ. Calif. Publ. Zool., 24: 1–124, 1922) estimated that its total range involved "less than four square miles." Between July 1957 and January 1958 the present distribution was investigated by live trapping and by watching for the characteristic tracks and arched burrows of kangaroo rats.

The area occupied by *D. h. morroensis* is gently rolling near the bay, becoming more level as it rises toward the hills in the south. The soil is a medium-textured sandy loam which supports a mixture of Coastal Sage Scrub and Coastal Strand, blending with the Chaparral community (Munz and Keck, El Aliso, 2: 87–105, 1949) on the hills at elevations from 250 to 300 feet above sea level.

The present range of *D. h. morroensis* was found to cover 4.8 square miles (Fig. 1), coinciding with the distribution of sandy loam soils. A few colonies were located on more compact soil in the low hills just east of Los Osos Creek. Kangaroo rats were not found in oak or eucalyptus groves, chaparral, damp areas with lush vegetation, steep-sided ravines,

or in large parts of the community of Baywood Park. These exceptions reduced the suitable habitat to less than 2.5 square miles.

Within the reduced area of suitable habitat, five vegetation types may be recognized: (*A*) Unused cleared land with a scattered growth of annuals. Numerous burrows and tracks were observed, indicating a high kangaroo rat population. (*B*) A homogeneous plant cover dominated by *Lotus scoparius*, with a few scattered clumps of grass growing under the larger plants. Numerous tracks and burrows indicated a population about as high as in *A*. A quadrat consisting of 36 traps at 30-foot intervals (about ¾ acre) was run for three nights

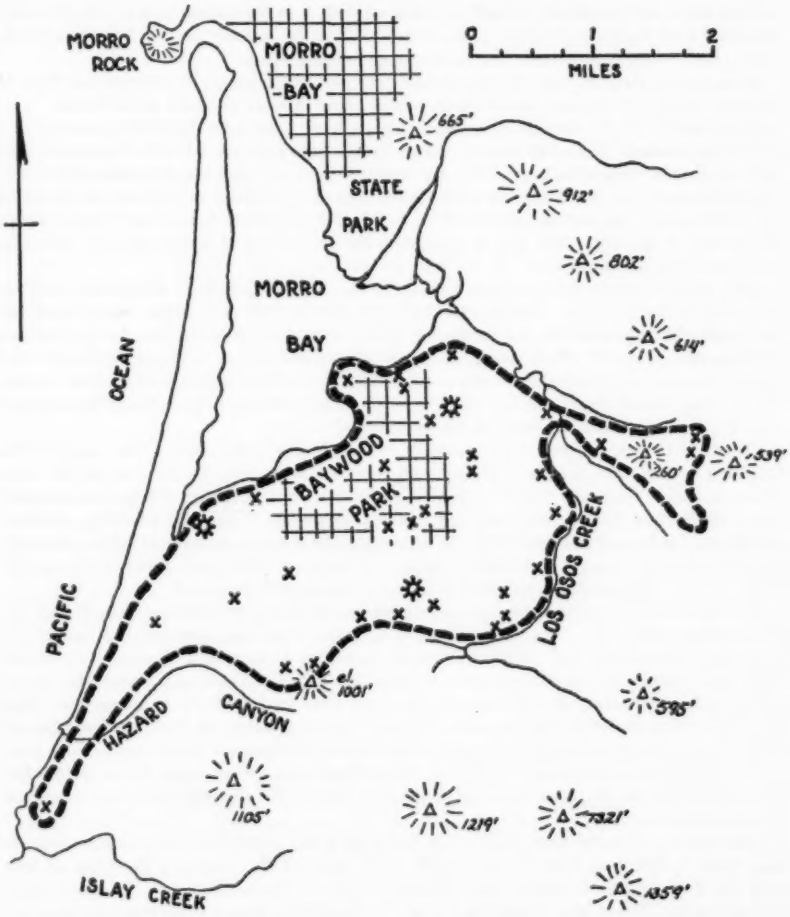


FIG. 1.—Map showing the approximate limits of the range of *Dipodomys heermanni morroensis*, indicated by the heavy dashed line. Trapping localities are shown by small x's; the starred circles show the location of the three quadrats. No rats were found in that portion of the range adjacent to the word "Hazard" in Hazard Canyon.

in August. The first night 14 rats were caught, 10 the second, and 9 the third. The same quadrat was run again in November, with a catch of 19, 7, and 7 rats on corresponding nights. These figures do not include retraps. (*C*) A widely spaced heterogeneous cover; very little grass present, the dominant plants being *Eriogonum parvifolium, Salvia mellifera, Artemisia californica, Croton californicus* and *Ericameria ericoides*. This is probably the most common vegetation type within the range. A quadrat like that mentioned above produced the following numbers of rats: in August, 5, 3, 0; in November, 2, 2, 2. (*D*) A heterogeneous cover with an abundance of grasses; important shrub species included *Lupinus chamissonis, Ericameria ericoides, Lotus scoparius* and *Eriogonum parvifolium*. A quadrat set here produced the following results: in August, 3, 2, 1; in November, 9, 3, 2. (*E*) Pastured grassland with *Lupinus arboreus*, a situation found at the colonies east of Los Osos Creek. Food plants other than grasses and lupine were not abundant.

In an area of about 40 acres in the southwestern part of the range, like Vegetation Type *D* although lacking in lupines, no kangaroo rats or signs of their presence were found.

Altitudinally, *D. h. morroensis* ranges from sea level to at least 1,000 feet, on top of a hill at the southern part of the range. Normally the hills are covered with chaparral above 250 feet, but in 1949 a fire burned the slopes of this particular hill, clearing about 100 acres. The subsequent growth of annuals in the burn apparently created conditions that permited the rats to move up into an unburned, favorable habitat which had always been present on the top of the hill. This idea is supported by the finding of a few rats still living in sections of the old burn.

Main burrows of *D. h. morroensis* appear to be simpler than those described for *D. h. tularensis* by Tappe (Jour. Mamm., 22: 117–148, 1941). Fifteen burrows were traced out as completely as possible in the loose soil. They were from 6 to 10 feet long, with two or three rooms, one of which contained a nest. Each had one or two main entrances and two or three escape routes which often ended blindly an inch or two beneath the surface. The average tunnel depth was between 6 and 12 inches. None of the burrows investigated were plugged, nor were any burrows found occupied.

Captive rats were offered plant materials collected within the range. The seeds of the following species were readily accepted, and occurred in at least 50 per cent of the areas where rats were trapped: *Corethrogyne filaginifolia, Lotus scoparius, Cirsium occidentale, Potentilla lindleyi, Chorizanthe californica, Salvia mellifera, Ericameria ericoides, Dudleya caespitosa, Lupinus chamissonis, Lupinus arboreus*. The stems and leaves of *Lotus, Dudleya, Lupinus* and *Bromus* sp. were also accepted. Although captives did occasionally eat the heads of ants and grasshoppers, plant foods were apparently preferred.

Associated animal species included *Peromyscus maniculatus* (Vegetation Types *C* and *D*), *Perognathus californicus* (Vegetation Types *B, C* and *D*, but least common in *B*, where rats were most abundant), and *Reithrodontomys megalotus* (Vegetation Type *D*). Potential predators observed included house cats, badgers, gray foxes, horned and barn owls, gopher snakes and rattlesnakes. Human activity does not seem to disturb *D. h. morroensis*, since they were trapped within 50 feet of dwellings in parts of Baywood Park. Introduction of house cats and destruction of habitat are probably the most important threats traceable to man.

Of 52 kangaroo rats examined, 46 had external parasites. Fleas were found on 38, lice on 19, and ticks on 18. Nematodes were found in one of the five rats that were examined for intestinal parasites.

Four pregnant females examined in July had 4, 3, 3 and 3 embryos. Two captive females gave birth to litters of 3 and 4 on 10 July 1957. One of the young in the litter of four died the first day, and disappeared, probably eaten by its mother. Of 47 rats trapped during August, 30 had gray immature pelage; in November, only 5 immature rats appeared among 53 animals trapped.

The development of the young born in captivity was similar to that described for *D. h. tularensis* (Tappe, *op. cit.*) and *D. m. merriami* (Doran, Jour. Mamm., 33: 494–495, 1952). The first fine hair was observed on the back of the head at an age of 10 days, eyes began

to open at 13 days, and weaning was complete at 26 days. Typical immature pelage was complete at 5 weeks. Adult weights and measurements were reached in 14 to 16 weeks, and adult pelage in 17 to 20 weeks. The youngest specimens trapped in the field were estimated to be 5 or 6 weeks old.

The hip stripe which characterizes this subspecies was formed on all six young born in captivity. Those having wide hip stripes at birth developed into adults with a very narrow, but complete, hip stripe. On young with a narrow stripe to start with, the hip stripe disappeared as the fur grew out. Of 32 wild adults trapped, two had complete hip stripes.—Glenn R. Stewart, *Oregon State College, Corvallis,* and Aryan I. Roest, *Calif. State Polytechnic College, San Luis Obispo.* *Received 6 October 1958.*

RECORD OF AN ALBINO PINE VOLE

An albino pine vole, *Pitymys* sp., was presented to the U.S. Fish and Wildlife Service, Washington, D.C., by E. V. Komarek, Birdsong Plantation, Thomasville, Georgia. This specimen was collected by him on 1 February 1950, at Boston, Georgia, and has been accessioned to the Biological Survey's collection as No. 287320, skin only. The measurements given are: total length 103, tail 24, hind foot 14 mm. Specific determination seems impossible from the data available.

The specimen is a pure albino, hairs being white to the basal portions; eye color is not designated; and it is apparently a young adult, as "1 embryo full term" is noted on the specimen label. It has glossy, rather short, silky textured fur.

Mutations in this genus have been noted by Handley (Jour. Mamm., 34: 262, 1953) and Hatt (Jour. Mamm., 11: 323, 1930), but this is apparently the first albino record of a North American *Pitymys.*—Viola S. Schantz, *U.S. Fish and Wildlife Service, Washington, D.C.* *Received 23 October 1958.*

ADRENAL WEIGHT CHANGES IN *MICROTUS*

Incidental to some attempts to modify experimentally the pituitary-adrenal axis of wild *Microtus californicus,* some adrenal weights considerably above the normal range were recorded. In view of current interest in the significance of adrenal weight changes in population dynamics (e.g., Christian, Jour. Mamm., 31: 247, 1950; Ecology, 37: 258, 1956), these data are reported along with some of the experimental findings.

To compare the adrenocortical responses of *M. californicus* during two different seasons of the year, animals were live-trapped in the field at weekly intervals during the late summer months (August and September) 1957 and during the spring months (March and April) 1958. Both samples were taken from a relatively dense population in the grassland and in the *Salicornia* marshes along the northeastern shore of San Francisco Bay in an area of approximately 2 acres. Animals for the field control sample were live-trapped in the field and killed by neck fracture; their adrenal glands were removed immediately and fixed in 10 per cent neutral formalin. Experimental and laboratory control voles were placed in individual cages with ample food, water and nesting materials and maintained in the laboratory for 10 days, at the end of which time they were killed and their adrenal glands fixed as above. Both adrenals were weighed out of formalin on a Roller-Smith 0–100 mg. balance. The weights of the paired adrenal glands from three animals killed in the field and from one animal from a group maintained untreated in the laboratory for 10 days were found to be two to three times greater than the mean weight of adrenals from other voles (Table 1).

Histologic study did not reveal any difference between the aberrant adrenals and the more normal sized glands of both the summer and spring samples. Although the aberrant

TABLE 1.—*Body and adrenal weights of male Microtus californicus*

SAMPLE	NO. OF ANIMALS	MEAN FINAL BODY WEIGHT, GM.	MEAN PAIRED ADRENAL WEIGHT, MG.	PAIRED ADRENAL WEIGHT-RANGE, MG.	PAIRED ADRENAL WEIGHT (MG.) / FINAL BODY WEIGHT (GM.)
Summer 1957					
Laboratory Controls	5	38.8	32.6	22.4–39.5	0.84
Spring 1958					
Laboratory Controls	10	33.5	38.8	19.6–57.9	1.16
Spring 1958 Aberrant					
Laboratory Controls	1	56.0	86.8		1.55
Spring 1958					
Field Controls	10	44.7	41.4	26.8–53.6	0.93
Spring 1958 Aberrant					
Field Controls	3	59.6	122.6	111.8–129.0	2.06

adrenals were from voles that were 30–65 per cent heavier than the mean "normal" sample, adrenal size showed no consistent correlation with body weight. For example, two individuals from the spring field sample of the same length and weight possessed adrenals weighing 129.0 and 53.5 mg. The organ weight/body weight ratios clearly show that the aberrant adrenals were truly "out-of-line." In addition to the five controls listed in Table 1, none of the 16 male experimental animals used in the summer study showed unusually large glands, whereas four of the 24 males of the spring collection were aberrant. Comparable numbers of females from both summer and spring seasons revealed no large glands. It is to be emphasized that the exceptionally large adrenals occurred in mice that were judged healthy by careful autopsy and histopathologic examination, and the presence of such voles in a population may raise some questions as to the reliability of adrenal enlargement as a criterion of population density "stress."

The results of unilateral left adrenalectomy indicate that male *M. californicus* had a functioning pituitary-adrenal axis during both study periods. The right adrenal gland is normally smaller than the left (an average of 8.6 per cent lighter in 29 males, 13.1 per cent lighter in 24 females); thus, hypertrophy could be recognized readily if the right gland were heavier at the end of the experiment (10 days later) than the left gland at the time of extirpation. The right adrenals of males of both the summer sample (7 animals) and spring sample (4 animals) showed marked compensatory hypertrophy, being on the average 33.0 per cent and 28.5 per cent larger respectively than the extirpated left adrenals. Right adrenal glands of the females of the summer collection (7 animals) were 26.9 per cent heavier than the left after similar treatment; surprisingly, however, the right adrenals of *post partum* females of the spring sample (3 animals) were 8.6 per cent *lighter* than the extirpated left glands, revealing no compensatory adrenal response in these mice. These observations may indicate maximum stimulation of the pituitary-adrenal axis during and immediately after pregnancy.

I am indebted to Howard A. Bern and Robert A. Campbell for their advice on this study.—DAVID A. MULLEN, *Dept. of Zoology (Cancer Research Genetics Laboratory), Univ. of California, Berkeley.* *Received 5 November 1958.*

THE RICE RAT IN SOUTHERN OKLAHOMA

The rice rat, *Oryzomys palustris texensis*, has been previously recorded from only two localities in Oklahoma (Whitaker, Jour. Mamm., 18: 102, 1937; McCarley, Tex. Jour. Sci., 4: 102–112, 1952). Whitaker established the presence of the species in the Mississippi

biotic district of Oklahoma when he captured two specimens in a flat of giant cane (*Arundinaria gigantea*) on the floodplain of the Mountain Fork River, 15 miles southeast of Broken Bow, McCurtain County. McCarley caught one adult male in a tall-grass prairie association 5 miles north of Colbert, Bryan County. This latter capture established the presence of the species in the Osage Savanna biotic district of Oklahoma.

In 1957, G. M. Sutton reported (personal communication) that he had observed nests of this species 3.6 miles north of Madill, Marshall County. On 11 July 1958, two adult male rice rats in non-breeding condition were caught in live traps at this locality. On 22 July 1958, an adult non-breeding female was captured at the same locality. This site represented the third locality in Oklahoma from which rice rats have been collected. The presence of *Oryzomys palustris* in this area extended the known range of the species about 40 miles northwest of Bryan County and well into south-central Oklahoma. The three Marshall County specimens have been placed in the collection of the Zoology Division of the University of Oklahoma Museum.

These three specimens were caught adjacent to one of a series of three man-made stock ponds, known locally as MacBeth's Pond, in a general vegetational association best characterized as tall-grass prairie. Water had seeped under or through the dam of the highest pond in the series and created a semi-aquatic community approximately 35 by 200 feet in size. The dominant vegetation here was *Eleocharis* sp., *Fuirena simplex, Juncus torryeyi* and *Typha* sp. The species of rushes and sedges had formed a dense tangled mat of vegetation which was laced with rodent runs. Other mammalian species caught in this semi-aquatic community were the cotton rat (*Sigmodon hispidus*), which may have been responsible for some of the runs, the wood mouse (*Peromyscus leucopus*) and the house mouse (*Mus musculus.*) The wood mice were caught only around the periphery of the marshy area.

Additional extensive trapping in Marshall County produced no other specimens of rice rats. It seems likely, however, that this species is more widespread in southern Oklahoma (and probably other portions of the eastern part of the state) than trap records have revealed. The meager data at hand indicate that the species occurs as small disjunct populations in such damp places as that described by Whitaker (*op. cit.*) and the MacBeth Pond area. The capture of a single individual in the comparatively xeric tall-grass prairie of Bryan County indicates that this habitat does not serve as a major barrier to the dispersal of this species.

This is a contribution from the University of Oklahoma Biological Station, Lake Texoma. Thanks are extended to George J. Goodman for identification of the plant species.—W. H. McCarley, *Dept. of Biology, Southeastern State College, Durant, Oklahoma.* *Received 13 November 1958.*

ANOTHER *REITHRODONTOMYS* FROM ILLINOIS

Two male *Reithrodontomys megalotis* were caught in a grassy area along a small branch of Defeat Creek, 2.5 miles south of Bradford, Stark County, Illinois, on 16 August 1958. In 175 trap-nights at this location, 2 *Microtus pennsylvanicus*, 3 *Blarina brevicauda*, and 16 *Peromyscus leucopus* were taken also.

These captures extend the known range of *Reithrodontomys megalotis* in Illinois approximately 56 miles southeast of the last published occurrence near Denrock, Whiteside County, Illinois (Klimstra, Jour. Mamm., 38: 522–523, 1957). Harvest mice probably occur sporadically throughout most of northwestern Illinois, north and west of the Illinois River.

Specimens have been deposited in the collections of the Cooperative Wildlife Research Laboratory, Southern Illinois University.—Howard J. Stains and Donald Stuckey, *Cooperative Wildlife Research Laboratory, Southern Illinois Univ., Carbondale.* *Received 8 December 1958.*

THE HISPID COTTON RAT IN NEBRASKA

On the night of 15–16 November 1958, Robert R. Patterson and I trapped 12 hispid cotton rats, *Sigmodon hispdius texianus*, 3½ mi. S, 1 mi. W Dawson, Richardson County, southeastern Nebraska. These specimens (KU 79157–68) provide the first record for the species in Nebraska, although its occurrence in the state was expected as cotton rats have been reported previously from several counties along the northern border of Kansas (Cockrum, Univ. Kansas Publ., Mus. Nat. Hist., 7: 184–187, 1952; Anderson and Nelson, Trans. Kansas Acad. Sci., 61: 306, 1958). The Nebraskan locality is the northernmost for the species in North America.

Cotton rats were trapped in ditches on both sides of a little-used road in the valley of the South Fork of the Nemaha River. Thick stands of slough grass (*Spartina pectinata*) and switch grass (*Panicum virgatum*) grew in the bottom of the ditches; foxtail (*Setaria lutescens*) and sunflower (*Helianthus* sp.) grew on the sides. The trapping site was bordered on the east by a fallow field and on the west by a cornfield. The following kinds of small mammals also were trapped at this locality: *Blarina brevicauda carolinensis, Reithrodontomys megalotis dychei, Peromyscus maniculatus bairdii, Peromyscus leucopus noveboracensis, Microtus ochrogaster ochrogaster, Synaptomys cooperi gossii,* and *Mus musculus* subsp.—J. Knox Jones, Jr., *Museum of Natural History, Univ. of Kansas, Lawrence. Received 16 December 1958.*

PORCUPINES IN THE CHIRICAHUA MOUNTAINS, SOUTHEASTERN ARIZONA

Erethizon dorsatum has been quite rare, though not nonexistent, in the Chiricahuas until the last decade or so when its numbers have obviously increased. W. W. Price and associates collected in the Chiricahua Mountains from 16 March to 5 September 1894 without reporting porcupines (Allen, Bull. Amer. Mus. Nat. Hist., 7: 193–258, 1895). Cahalane (Jour. Mamm., 20: 418–440, 1939) collected during the summers of 1932 and 1933 without seeing even signs of porcupines.

Although scientific collectors have missed the animal, it is certain that a few individuals have been present. The ease with which porcupines can be observed, once sighted, and their unmistakable effect on a hunter's dog, make reports of their occurrence by laymen beyond reasonable suspicion. Dice and Blossom (Carnegie Inst. Wash. Publ. 485, 1931) report two porcupines killed in the Chiricahua Mountains in the period 1904–1931, but believed the animal extinct in 1931. Cahalane (*op. cit.*) placed *Erethizon* on a hypothetical list for the mountains on the bases of a sight record by Mrs. Maloney of Cave Creek, and a report by the Lee brothers of Paradise, that "in nearly twenty years of lion hunting . . . seen only three." The same Mrs. Maloney, still resident on Cave Creek, recalled for the present writer that it was in 1908 that one of the family dogs was quilled by a porcupine, and that she had seen a few animals since then. William Reed, also of Cave Creek, recalls that he saw a very few porcupines in the Fly Peak and Cima Cabin areas while working for the Forest Service, 1925–1934, but he saw none in Cave Creek Canyon from 1905 to 1911.

Today it is obvious to any biologist traveling in the Chiricahuas that porcupines can be rated as at least fairly common, and that they are found in practically all vegetation types. E. L. Cockrum has contributed the following sight records for the Chiricahuas: Buckelew Cave, west end Blue Mountain, 17 mi. south San Simon, in mesquite, 26 July 1954; Maloney Ranch, Cave Creek Canyon, 4 mi. southwest Portal, in riparian habitat, 29 May 1955; mine tunnel, ¾ mi. northwest Portal, mesquite area, 14 August 1955. The records of the Southwestern Research Station, American Museum of Natural History, Cave Creek Canyon, show two specimens seen at Buckelew Cave 26 May 1956; one male was taken and is in the collections of the Station. Specimens have been taken by the mammalogy classes of E. L. Cockrum, University of Arizona, in the years 1956–1958.

From July to 14 November 1958, porcupines have been seen repeatedly by staff and

visiting scientists at the Southwestern Research Station. Most of these records have been in the oak woodland-riparian habitat of Cave Creek Canyon, but also on record are: creosote bush area, 8 mi. south San Simon, 1 July; oak-pine below Fly Peak, 15 July; ponderosa pine, Rustler's Park, October; spruce-aspen on Fly Peak, 11 November.

Questioning of residents of the Cave Creek and Portal areas indicates that this increase in porcupines began between 1940 and 1950—ROBERT M. CHEW, *Dept. of Biology, Univ. of Southern California, Los Angeles 7.* *Received 19 November 1958.*

[Contribution from Southwestern Research Station, Amer. Mus. Nat. Hist., Portal, Ariz.]

PORCUPINE QUILLS IN VISCERA OF FISHER

There are many reports of carnivores receiving serious damage from the quills of the Porcupine, *Erethizon dorsatum*, in the eyes, nose, mouth and pads. However, little seems to be known about internal damage from quills. In this respect the following observations are of interest.

While autopsying 25 fisher, *Martes pennanti*, for an organ-weight study, quills were found in the following unusual places. In specimen No. 15, the tip of a quill over 1½ inches long was found buried partly in the left adrenal gland and partly in the left adreno-lumbar vein. No. 20 had a quill almost 2 inches long buried in lung tissue. Apparently the quill had entered through the trachea and not the esophagus. In No. 17, a quill over an inch long was completely buried in omental fat. Furthermore, no less than five quills over 1½ inches long were found protruding from the stomach into the peritoneal cavity. Two more quills were found protruding over an inch from the small intestine into the peritoneal cavity.

Specimen No. 17, with eight quills in its viscera, was apparently in good health for the stomach contained the remains not of a porcupine, as might have been expected, but of a marten, *Martes americana*. Because these three animals had been deep-frozen for several months, it was impossible to determine whether any had developed peritonitis. Nos. 15, 17 and 20 were all adult males.

Since the porcupine is the favorite food of the fisher, it might be expected that the animals would either take care not to swallow the quills or have developed an inherent resistance to peritonitis. The quills found had obviously been chewed, but they were apparently quite undissolved and still needle sharp.

Other carnivores known to prey on the porcupine include the cougar, *Felis concolor*, the timber wolf, *Canis lupus*, the coyote, *Canis latrans*, the bobcat, *Lynx rufus*, and probably the lynx, *Lynx canadensis*. The cougar, according to Young and Goldman (THE PUMA, MYSTERIOUS AMERICAN CAT, 1946) kills porcupines by turning them over and slashing at the unprotected abdomen with the claws. In spite of this, these authors have found scats with as much as 80 per cent of sharp quills. How the cougar continues to live after such a meal is worth study. Wolves have been reported killing porcupines by grasping the nose firmly in the mouth and shaking until dead (Young and Jackson, THE CLEVER COYOTE, 1951). The fisher, the bobcat and the lynx presumably use the same method as the cougar. Manville (Jour. Mamm., 39: 439, 1958) reported finding quills in the stomachs of three of eight bobcats examined. However, in only one of them was a quill actually embedded in the wall of the stomach. Hamilton and Hunter (Jour. Wildl. Mgmt., 3: 99–103, 1939) found remains of porcupine in 8.6 per cent of 143 bobcat stomachs examined.

It would be interesting to discover if any of these forest-living predators have been found dead in the field, either from quills penetrating vital organs or from peritonitis.

The 25 fisher examined were trapped during the 1956–57 season by commercial trappers and were forwarded to me through the courtesy of the Division of Research, Department of Lands and Forests, Ontario, Canada.—M. J. DANIEL, *Dept. of Zoology, Univ. of British Columbia, Vancouver.* *Received 9 December 1958.*

SUCKERFISH ON PORPOISE

On 14 May 1955, over 35 fathoms of water in the Gulf of Mexico, 90 miles south of Calcaseiu Pass, near Sabine Bank at 28° 10′ S and 93° 20′ W, a group of porpoises swam under the bow of a boat. Attached to the side of one porpoise was a large suckerfish. This observation was made by Mahnken, photographer on the expedition of the American Petroleum Institute from the Scripps Institution of Oceanography at La Jolla, California.

Mahnken brought the data to Gilmore who identified the porpoise as clearly of the same beaked form and spotted coloration as the spotted porpoise, *Stenella plagiodon*, three specimens of which he had previously collected at Rockport, Texas, on 21 March 1951.

From its presence on a cetacean, the size and location of the disk, and other features recognizable from Mahnken's photographs, Ernest Lachner of the U.S. National Museum (who has just revised the Echeneidae) identified the suckerfish as probably *Remora australis*, the whale-sucker. Mahnken's observations for ten minutes were as follows: The suckerfish was about 20 inches in length and of a uniform gray coloration. It clung tenaciously to the side of the host despite the porpoise's speed of about 10 knots, that of the ship. In fact, it worked its way entirely around the body of the porpoise, by manipulation of its sucking disk, passing ventrally at first from the left side and coming up again on the right side, without any time losing its grip or even losing position backward on the body!

PLATE I
Spotted porpoise, *Stenella plagiodon*, with suckerfish attached. Photo by Thomas Mahnken.

Plate I shows part of the circuit that was without apparent cause, unless the whale-sucker was shifting position to avoid possible contact with the side of the vessel, only a few feet away, and thus easily visible to the fish. The shifting of position on the porpoise's body, without detachment or loss of "altitude," was considered remarkable.—THOMAS MAHNKEN, *P.O. Box 582, Del Mar, and* RAYMOND M. GILMORE, *Natural History Museum, San Diego, California.* *Received 4 November 1958.*

NOTES ON THE SPOTTED DOLPHIN IN THE GULF OF MEXICO

Moore (Amer. Midl. Nat., 49: 130, 1953) indicated that the spotted dolphin, *Stenella plagiodon* (Cope), is common in offshore waters of Florida. This probably can be applied to the species in offshore waters of the entire Gulf of Mexico, and along much of the Atlantic seaboard. Despite this apparent frequency, Gunter (U.S. Fish and Wildlife Serv., Fishery Bull. 89: 548, 1954) noted that little is known of the natural history of this species. In an earlier paper (Caldwell, Jour. Mamm., 36: 467, 1955) I presented records and random notes for this species in the western Gulf. Knowledge of the spotted porpoise is so embryonic that it is worthwhile to record additional notes, fragmentary though they are, to aid in a clearer understanding of this species. The following observations were

made for the most part while I was a visiting investigator, through the courtesy of Harvey Bullis, Jr., on the U.S. Fish and Wildlife Service's M/V *Oregon* during a tuna-fishing cruise to the northern Gulf of Mexico in July 1956. Sight records are summarized in Table 1, and the sighting numbers will in part be used in the discussion below. My identifications were corroborated by William E. Schevill of the Woods Hole Oceanographic Institution after he examined Kodachrome slides made of the living animals in the water. Most of the observations were made with the aid of 7 × 50 binoculars, although the porpoises were usually near the vessel.

In rising to blow, as they ran before the ship's bow, the porpoises usually first exposed the tip of the snout, then the remainder of the head, followed by the arch of the back and the dorsal fin; they then dived beneath the surface. The tail flukes were never seen exposed during a roll.

There are frequent reports of an instinctive animosity by porpoises toward sharks. Contrary to this, at position 4 (Table 1) a large white-tip shark, *Pterolamiops longimanus* (Poey), swam through the midst of several of the porpoises with no apparent notice on the part of fish or mammal.

TABLE 1.—*Observations of spotted dolphins in the northern Gulf of Mexico*

DATE	POSITION IN TEXT	GEOGRAPHICAL POSITION LAT. N	LONG. W	APPROXIMATE DEPTH IN FATHOMS	APPROXIMATE MILES TO NEAREST LAND	NUMBER OF INDIVIDUALS
		Position of M/V *Oregon*				
19 VII 56	1	30°05′	88°28′	10	7	3
21 VII 56	2	28°20′	88°37′	900	53	2
22 VII 56	3	28°35′	88°10′	1160	59	8
24 VII 56	4	28°45′	88°03′	900	60	10
26 VII 56	5	28°50′	87°58′	900	64	2
26 VII 56	6	28°59′	87°49′	800	70	8
26 VII 56	7	28°53′	87°57′	850	65	2
26 VII 56	8	29°22′	88°05′	50	51	8
		Position of sport-fishing vessel				
19 IV 58	9	30°05′	85°46′	11	3	4

Sexual behavior.—In my previous paper (*op. cit.*: 468) I described what was presumed to be copulation. Although the act was not actually witnessed per se, the actions of the porpoises then and during the presently described observations were so similar to those described by Tavolga and Essapian (Zoologica, 42: 12f., 1957) for captive *Tursiops truncatus* (Montague), and to those I have observed for that species in captivity, that it was assumed precopulatory and copulatory behavior were the activities witnessed. Some of the porpoises at position 4 appeared to be so engaged. Several pairs of adults, presumably of opposite sex, were observed together. Frequently one turned onto its back or side and swam close to the other, often rubbing at right angles (about the level of the dorsal fin) against the back of the latter, as the second swam in a normal horizontal position. One pair was seen in the assumed copulatory position, with accompanying splashing.

Other actions by adult pairs involved swimming in a horizontal position, but tilted inward and with the anterior regions in contact, so that a V was formed by the pair. At vessel position 4, several individuals were seen to "stand" vertically in the water, with the jaws breaking the surface. When another individual, swimming in a normal position, brushed the vertically positioned one, the latter's jaws were opened slowly and held open for several seconds.

Although it could not be determined whether the act was associated with sexual behavior or mere play, on several occasions spotted porpoises were observed to jump clear of the water—sometimes leaping in a low arc, and sometimes jumping straight up, arching the back, and falling tail first into the water.

The presumed mating behavior shown by the porpoises during this July cruise complements my previous findings and extends the mating season in the Gulf of Mexico at least from early May to the latter part of July.

Color.—Several of the adult-sized animals at positions 3, 4 and 6 had white lower jaws (from tip to gape) and white-tipped upper jaws. The oral edge of the upper jaw also was white. In some of these, the color appeared pink. I have observed similar pink coloration in the light gray or white areas on captive *Tursiops truncatus*, during the summer mating season, and there appears to be an association of such color with breeding. All the individuals in a school were not so marked—about half of the adult-sized porpoises had dark jaws. Nor could the color be linked with sex, presuming the pairs to be of opposite sex, since all three combinations of jaw color were seen in paired individuals.

I have noted previously the calves of spotted porpoises are not spotted, although the ground color, of various shades on different parts of the body, appears to be generally the same at all ages. This was again demonstrated, even more clearly than before, when two adult-calf pairs (presumably mother and calf) were observed for several minutes each as they swam under the bow of a sport-fishing boat at position 9. The close-inshore occurrence of the spotted porpoise at this position, and at position 1, is noteworthy since data given by Moore (*op. cit.*: 131) showed a preference by this species for an offshore habitat.

I wish to thank William W. Anderson, Frederick H. Berry and Jack W. Gehringer, all of the U.S. Fish and Wildlife Service at Brunswick, for helpful comments on the final manuscript.—DAVID K. CALDWELL, *U.S. Fish and Wildlife Service, Brunswick, Georgia.* *Received 24 November 1958.*

SPERM AND PIGMY SPERM WHALES STRANDED IN THE GULF OF MEXICO

In a summary of whaling-ship log-book records for sperm whales, *Physeter catodon* Linnaeus, Townsend (Zoologica, 19 (1): charts A and B, 1935) listed this species as having been taken in the Gulf of Mexico only from March through July. The only published records of sperm whale strandings in the Gulf include a large male stranded at Port Arthur, Texas, about 10 March 1910 (Newman, Science, 31: 631, 1910); a fetal male stranded at Englewood, Charlotte County, Florida, on 29 August 1939; and skeletal material from Alligator Peninsula, Franklin County, Florida. The last two records were listed by Moore (Amer. Midl. Nat., 49: 127–128, 1953).

The following two sperm whale records are of special interest since they represent the first reported strandings during the winter months in the Gulf of Mexico. A large sperm whale, 48 feet in length, was beached in the vicinity of Naples, Florida, about November or December 1955. Personnel of the U.S. Fish and Wildlife Service measured and photographed the specimen before the carcass was towed to sea by a U.S. Coast Guard vessel (E. L. Arnold, Jr., personal conversation). Although partially decomposed, the animal appears from the photograph to have been a male. A second individual of this species came ashore on the beach about 5 miles northwest of Port St. Joe, Gulf County, Florida, on 9 December 1957. The animal was alive and lived for several hours after its discovery. It was a young individual, as evidenced by its small size (estimated from photographs at 18–19 feet in over-all length) and by the fact that its teeth had not yet erupted through the gums. Photographs also show the animal to be uniformly dark, with the exception of the interior of the mouth, which is white; to have the expected single left-set blowhole; and to be a male. A cold, 16–18-knot onshore wind was reported and this may have aided in effecting the stranding. A similar, but undated, stranding in Ireland of a comparably sized

TABLE 1.—*Measurements of Galveston specimen of Kogia breviceps*

FEATURE EXAMINED	INCHES	THOUSANDTHS
Total length (to notch in flukes)	84	1000
Width of flukes	22	262
Length of left flipper	14	167
Dorsal fin height	7	83
Dorsal fin length	12	143
Snout tip to rear of dorsal fin base	51	607
Snout tip to blowhole	7	83
Snout tip to eye	12	143
Notch in flukes to rear of dorsal base	33	393
Notch in flukes to flipper base	45*	536
Body depth at base of dorsal	20	238
Maximum body depth	22	262
Width of dorsal at base†	11	131

* Measurement estimated from photographs.
† Not included by Gunter, Hubbs and Beal.

individual with non-erupted teeth was reported by Fraser (*in* Norman and Fraser, FIELD BOOK OF GIANT FISHES, WHALES AND DOLPHINS, 1949).

There are apparently only three previous records of the rare pigmy sperm whale, *Kogia breviceps* (Blainville), in the Gulf of Mexico. One of these was a female which gave birth while stranded at St. Petersburg Beach, Florida, in November 1949 (Moore, *op. cit.*: 129). The other two individuals were reported by Gunter, Hubbs and Beal (Jour. Mamm., 36: 263, 1955) from Texas—a female from Mustang Island on 27 December 1948, and a specimen from Padre Island on 7 February 1954. We now add two more Gulf records. The first of these, tentatively identified as a female from photographs, was found ashore about 0800 on 6 December 1957, on the beach within the city limits of Galveston, Texas. Various factors of tides and position of the animal on the beach indicated that it had washed ashore sometime during the night. When first examined at 0930, by Inglis, the animal was still alive. It had a deep wound on its back to the right of the dorsal fin. The wound appeared to have been caused by a shot or a puncture by some spear-like implement, and was probably a contributing cause to the animal's being washed ashore. The day was cold and stormy, with a strong onshore wind. Body measurements, made by Inglis, are listed in Table 1. The skull, unfortunately, was lost, but the remainder of the skeleton will be placed in the University of Florida Collections. A second individual washed ashore dead about 3 miles east of Destin, Okaloosa County, Florida, on about 1 April 1958. The animal, clearly a female from photographs furnished us, was either buried or washed away before measurements could be made. It is roughly estimated from the photographs to have been about 8–9 feet in over-all length. The color was dark above, shading to lighter (but not white) beneath. Hubbs (Jour. Mamm., 32: 408, 1951) noted that a specimen of this species from California had ". . . bracket-like marks . . . disposed on the two sides of the head between the eye and flippers . . . ." Photographs presented in that paper clearly show the marks. The pictures taken of our Florida specimen show similar markings, except that the upper limb of the bracket is only vaguely indicated—giving more the appearance of an L, with the lower limb directed forward. The photographs of our Texas specimen are all from such an angle that only the lower part of the bracket marks can be seen. These are quite clear, but it cannot be stated that the upper portion of the bracket was present. Gunter, Hubbs and Beal (*op. cit.*: 267) noted that photographs of their Texas specimens do not show such marks.

We wish to thank William A. Anderson, Frederick H. Berry, and Jack W. Gehringer, all of the U.S. Fish and Wildlife Service at Brunswick, for helpful criticisms of the completed manuscript.—DAVID K. CALDWELL, *U.S. Fish and Wildlife Service, Brunswick, Georgia,* ANTHONY INGLIS, *U.S. Fish and Wildlife Service, Galveston, Texas,* AND J. B. SIEBENALER, *Florida's Gulfarium, Fort Walton Beach, Florida.* *Received 24 November 1958.*

THE BACULUM OF *POECILICTIS LIBYCA*

Recently several specimens of *Poecilictis libyca* were obtained by U.S. Naval Medical Research Unit No. 3 stationed in Cairo, Egypt. These specimens are from Giza Province and were obtained at or near the edge of the desert on the west side of the Nile. Two bacula were saved by Harry Hoogstraal and these are now Chicago Natural History Museum nos. 89583 and 89585.

I can find no citation in the literature to a description of the penis bone of *Poecilictis*. Didier (Mammalia, 11: 30–43, 139–152, 1947; 12: 67–70, 1948) figured and described the bacula of many other genera and species of mustelids, but he apparently had no material representing *Poecilictis* inasmuch as no reference is made to it in any of the above papers.

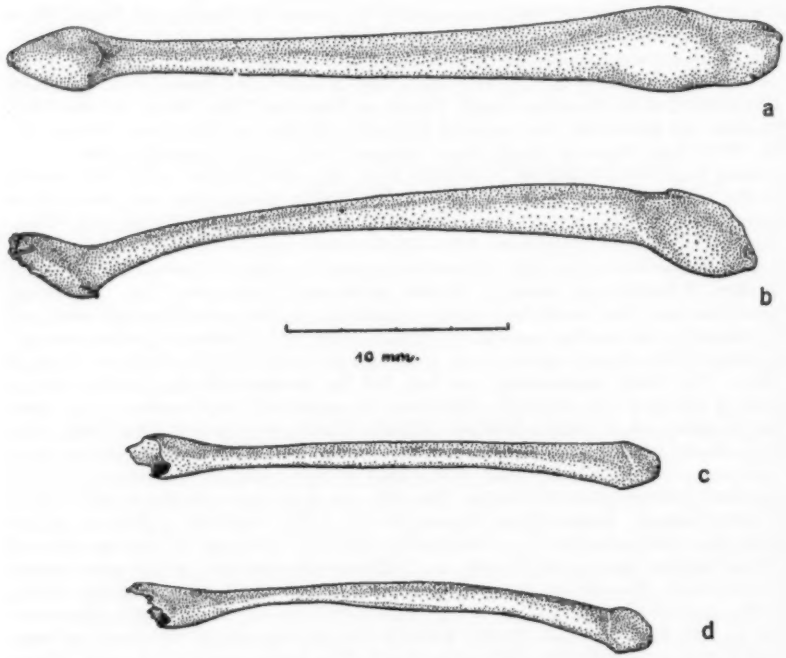


FIG. 1.—Bacula of *Poecilictis libyca*; *a* and *b*, ventral and lateral views of adult baculum, CNHM 89583; *c* and *d*, ventral and lateral views of immature baculum, CNHM 89585. Drawings by Mrs. Patricia Isham.

The baculum of adult *Poecilictis libyca* (Fig. 1*a,b*) is large and robust for an animal of its size (total length about 400 mm.). The basal end of the bone is rugose; the shaft is smooth and without pits; the distal end is "tear-drop" shaped and is attached to the shaft at an oblique angle. The dorsal surface of the shaft is convex with only a faint suggestion of the urethral groove near the proximal end.

Measurements of the adult baculum (no. 89583) are: Length (taken from point to point, not following the slight curve) 32.8 mm.; vertical diameter of proximal end 3.1 mm.; vertical diameter of distal end (greatest diameter of tip taken at an angle) 4.0 mm.; breadth of shaft at middle 1.9 mm.; breadth of proximal end 3.3 mm.; breadth of distal end 2.3 mm.

The immature baculum (no. 89585, Fig. 1 *c,d*) is smaller in all dimensions. The basal end lacks the rugose condition; nor has the length of the adult baculum been attained. The distal end is still in the process of ossification and is cup-shaped. The hollow of the cup is filled with cancellous bone tissue which appears to be the center of proliferation of the osteoblasts forming mature bone. Measurements of this immature baculum (about three-fourths grown) are: Length (taken from point to point, not following the slight curve) 22.7 mm.; vertical diameter of proximal end 1.9 mm.; vertical diameter of distal end 2.3 mm.; breadth of shaft at middle 1.2 mm.; breadth of proximal end 2.1 mm.; breadth of distal end 1.9 mm.

These bacula do not resemble those of any of the genera or species of Mustelidae figured by Didier.—Henry W. Setzer, *U.S. National Museum, Washington 25, D.C. Received 4 December 1958.*

A BADGER-SKUNK ENCOUNTER

An encounter between a badger, *Taxidea taxus,* and a skunk, *Mephitis mephitis,* was observed on 30 October 1958, for a period of about ten minutes. The badger was seen pursuing the skunk for about 100 feet along the Williams Fork road, Grand County, Colorado. Both appeared to be tired and winded. Odor of skunk was sharp. The animals turned downhill through sagebrush with the badger on several occasions biting the skunk's hind leg. Once or twice the badger may have bitten the skunk's back. They reached a grass-willow stream bottom, by which time the badger appeared unable to see or scent the skunk. The badger slid his face and eyes in the grass as if to clear his vision. He stopped occasionally and apparently proceeded toward the skunk by sound alone.

Periodically the skunk and badger faced each other, making short offensive charges from which the other retreated. Finally, after several hesitant, half-hearted movements toward the skunk in the willows, the badger moved off through the sagebrush, apparently giving up the chase.

Returning to the scene 1½ hours later (5 PM), we found the skunk still in the willows, pugnacious, but apparently not seriously injured. The badger was not in evidence.

The skunk appeared to be mature; the badger less than full grown.—Paul F. Gilbert, *Colorado Game and Fish Dept.,* and Ralph R. Hill, *U.S. Forest Service, Denver, Colorado. Received 19 November 1958.*

BRACHIAL-ANTEBRACHIAL STRIPES ON A STRIPED SKUNK

On 16 August 1958 an adult male striped skunk, *Mephitis mephitis,* was found dead on Illinois Highway 127, ½ mile north of Posey in Clinton County. This animal had a distinct white stripe approximately ½ inch wide on the outside of each front leg from near the upper end of the humerus to approximately ½ inch above the carpals. To our knowledge, previous observations of such stripes have not been reported. As the animal was badly decayed, only the bones of the right rear foot were collected (HJS No. 862).—Howard J. Stains and Donald Stuckey, *Cooperative Wildlife Research Laboratory, Southern Illinois Univ., Carbondale. Received 8 December 1958.*

SIKA DEER ON ISLANDS IN MARYLAND AND VIRGINIA

A heard of exotic deer has resided on James Island, Maryland, in Chesapeake Bay, since being released there in 1916. Speculation concerning the identity of these animals has been prevalent in recent years, some people believing them to be hog deer, *Axis porcinus* (see Presnall, Jour. Wildl. Mgt., 22: 45–50, 1958). In March and April of 1958 these deer stimulated considerable interest when a large portion of the herd died from malnutrition. Skulls were collected from 161 animals that perished at this time and some of these were compared with material in the U.S. National Museum and the Academy of Natural Sciences of Philadelphia.

Based on comparison with material in the above mentioned institutions and descriptions in the literature, it is concluded that these deer are sika deer, *Cervus nippon*. Upper canine teeth are present; the auditory bullae are smaller than the occipital condyles; the nasal bones protrude only about ¼ inch beyond the junction with the maxillae. Adult hog deer are not spotted the year round whereas these sika deer are spotted all year, the spots being especially noticeable in summer.

In addition, the fact that sika deer are usually kept in parks and zoos whereas hog deer are rarely so kept would make sika deer more available to purchasers of exotic deer. Hog deer are tropical in distribution, and so less likely to thrive in Maryland, whereas sika deer live in temperate climates. According to Lydekker (The Deer of All Lands. Rowland Ward, London, 1891) sika deer are sociable animals running in herds, while hog deer are more solitary in nature. The James Island deer are almost always seen in groups varying in size from 6 to 60 animals.

The antlers of the James Island deer are probably the primary cause for the confusion between sika and hog deer. The antlers are relatively small and have only two or rarely three points per antler. Few antlers are over 8 inches long and a 14-inch one is uncommon. The antler beam diameter is less than one inch at the base.

According to eye-witness accounts, four or five sika deer were released on James Island about 1916 by Clemment Henry, who had kept these deer in an enclosure near Cambridge, Maryland, for an unknown period before releasing them on the island. The deer on James Island have increased and spread onto nearby Taylor's Island and also onto the mainland of Dorchester County. An estimated 270 deer existed on the island in the fall of 1957 (Flyger and Warren, Proc. 12th Annual Conf. S.E. Assoc. Game & Fish Comm., 1958).

Charles Law of Berlin, Maryland stated that he purchased five sika deer (2 males and 3 females) from a man in Cambridge, Maryland, in 1920. These deer were held in an enclosure near Berlin for several years. During this time three young were born and one of the original males died. Dr. Law sold these deer to a man who in turn released them on Assateague Island. The deer moved south on the island to the Chincoteague National Wildlife Refuge in Virginia, where they multiplied and have become quite numerous. The author verified the identity of these animals in July 1958, at which time living animals and some shed antlers were seen. Based on these circumstances it is concluded that the sika deer on Chincoteague Island are probably from the same stock as are the deer on James Island. Jacob M. Valentine, Jr., the refuge manager, estimated that the herd exceeded 100 head. There are no records of this herd having expanded onto nearby Chincoteague Island or the mainland.

I am most grateful to John Warren of the Maryland Game and Inland Fish Commission for help in gathering much of this information and to David H. Johnson of the U.S. National Museum and Karl F. Koopman of the Academy of Natural Sciences of Philadelphia for making available the collections of these institutions.—VAGN FLYGER, *Dept. of Research and Education, Annapolis, Maryland.* *Received 31 October 1958.*

[Contribution No. 124, Maryland Department of Research and Education; P.R. Proj. W-34-R.]

TECHNIQUE FOR TRAPPING SMALL TUNDRA MAMMALS IN WINTER

In a study of the sylvatic life cycle of the parasite *Echinococcus multilocularis* (Cestoda: Taeniidae) on St. Lawrence Island, Alaska, it has been necessary to obtain series of tundra voles (*Microtus oeconomus*) and tundra shrews (*Sorex tundrensis*) at bi-monthly intervals throughout the year. Initially, this presented a problem in trapping technique, especially during the winter months, for this locality has an arctic maritime climate characterized by persistent high winds and frequent precipitation. Snow covers the ground from October through May and is drifted continually by winds averaging nearly 20 mph in velocity. The vegetation is composed principally of decumbent shrubs and forbs no more than a few inches tall, with no sheltering arborescent forms whatever. Winter temperatures range from +15° to -20°F.

The small mammals are active beneath the snow in winter, and one can find runways at the interface of snow and earth by excavating almost anywhere in the better habitats. During occasional brief periods of calm weather, snap traps have been set in such excavations with highly successful results. Under the more usual conditions of high winds and frequent snow squalls, however, these open excavations filled with snow within a few minutes and were useless as trap sites. An effective wind- and snow-proof cover for each trap site was needed, preferably one which could be constructed from some inexpensive material available locally in large quantities. Empty metal oil drums, which are abundant in many Alaskan Eskimo villages, proved to be ideal material. They were utilized as follows:

Two covers were obtained from each drum by cutting off both ends 4 to 6 inches from the rims (Fig. 1, *A*). Cutting was done with an axe, and the operation required but a few minutes per drum. Distortions in the shape were hammered out with the back of the axe, and the perimeter of the cut edge was enlarged slightly in this way. With a round-pointed shovel, a cylindrical excavation approximately 15 inches in diameter was cut in the snow, down to the ground level. Excess snow was cleared from the runways at the bottom, and a snap trap baited with English walnuts was set at each runway entrance. One of the oil drum covers was then placed over the excavation, tamped down lightly, and twisted several times in order to seat it well into the snow (Fig. 1,*B*). The latter procedure was of primary importance for completely excluding surface weather from the excavation. This emphasizes one of the advantages of covers made from oil drums in contrast to other

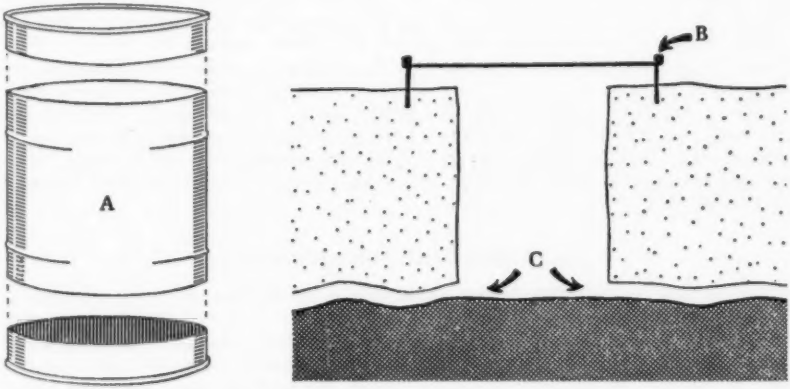


FIG. 1.—Trap site covers constructed from oil drums: left, a drum (*A*) with both ends cut off; right, cross section of a trap site showing the cover (*B*) seated into the snow and runways (*C*) entering at the ground level.

materials: the circular form and heavy metal construction facilitate forcing the cut edge into the snow and effectively sealing off the inner chamber.

The traps were checked twice daily to avoid loss of specimens by cannibalism, a factor which was especially important in winter. A sharp blow at any point on the rim of each cover was sufficient to loosen it for easy removal, and after the traps had been examined and the captured animals removed, the cover was replaced in its original position with a minimum of disturbance to the runways or to the excavation itself. This has been done with relative ease even in blizzards with 40–50 mph winds.

Other advantages of the oil drum covers are that they are heavy enough to resist being blown away in high winds, and they are extremely durable. They can be left out of doors for several years without serious deterioration by weathering.—Francis H. Fay, *Arctic Health Research Center, Anchorage, Alaska. Received 29 December 1958.*

PLASTIC TILES AS DROPPING BOARDS FOR POPULATION STUDIES OF SMALL MAMMALS

A modification of the dropping-board technique for surveying small mammal populations as described by Emlen *et al.* (Jour. Wildl. Mgt. 21: 300–314, 1957) was tested on an area of native tall-grass prairie near Mahnomen, Minnesota, in the summer of 1958.

The study was part of a long range project on prairie game and non-game species sponsored jointly by Pittman-Robertson Project W-11-R, Minnesota Department of Conservation, and several departments of the University of Minnesota.

Tan-colored plastic wall tiles 4¼ in. square were used in place of 4-in. plywood squares. The tiles, readily available from house-furnishing stores or mail-order houses, are cheaper ($2.60 *vs.* $3.12 per hundred as purchased and cut in Wisconsin), lighter (3.1 lbs. *vs.* 10.1 lbs. per hundred), less bulky for transport and storage (117 cu. in. *vs.* 452 cu. in. per hundred), more resistant to rodent chewing, termite damage and decomposition, and easier to clean. Tiles, like the aluminum squares of Emlen *et al.* (*op. cit.*), are probably more easily disturbed by wind and animals and the droppings on them more subject to soaking by condensation.

In efficiency the two proved to be very similar in a test in which 50 boards and 50 tiles were set out alternately at 25-ft. intervals and exposed for 20 days—a total of 1,000 exposures for each type. The positions of the wood and plastic boards were switched after 500 exposures of each had been made. The incidence of droppings on wood and plastic tile was, for *Microtus pennsylvanicus*, 131 and 138, respectively; for *Peromyscus maniculatus bairdi*, 58 and 52; for *Zapus hudsonius*, 9 and 5; for *Sorex cinereus*, 53 and 83; and for *Blarina brevicanda*, 4 and 5. Chi-square tests showed that the occurrences of *Microtus* and *Peromyscus* droppings on the two types of boards were not significantly different. *Sorex* showed a significant preference for the plastic boards. For all species combined the incidence was 255 and 283 (Chi-square, 1.46; probability of a greater difference due to chance, .24).—John R. Tester, *Museum of Natural History, Univ. of Minnesota, Minneapolis,* and John T. Emlen, Jr., *Dept. of Zoology, Univ. of Wisconsin, Madison. Received 30 October 1958.*

A SIMPLE TRAP FOR SQUIRRELS

For the past ten years the Zoology Laboratory of the Institute for Medical Research, Malaya, has been using a locally made trap principally for studies of rats. The trap used is of galvanized wire mesh, comprising a framework of stout galvanized wire over which a mesh of about 1 cm. diameter is woven by hand. It consists of a cage 30 × 15 × 15 cm. with an external door closed by two spiral springs and held open by a lever and a bait hook as in the diagram (Fig. 1). Bought in batches of about 50, these traps cost about Malayan dollars 2.50 each (approximately $.85 U.S.). Baited with sweet potato (*Ipomoea batatas*) this trap has proved efficient for rats.

For work with squirrels and tree-climbing rats, a simple attachment has been made for setting these traps high in trees. This consists of a piece of stout wire about 3 m. long, doubled, with the loop passing through a small tin can such as the one in which 50 cigarettes are sold. The two ends are passed up through the mesh on one side of the trap and then down through the other side so that they project about 30 cm. through the bottom of the trap. The tin can is filled with concrete.

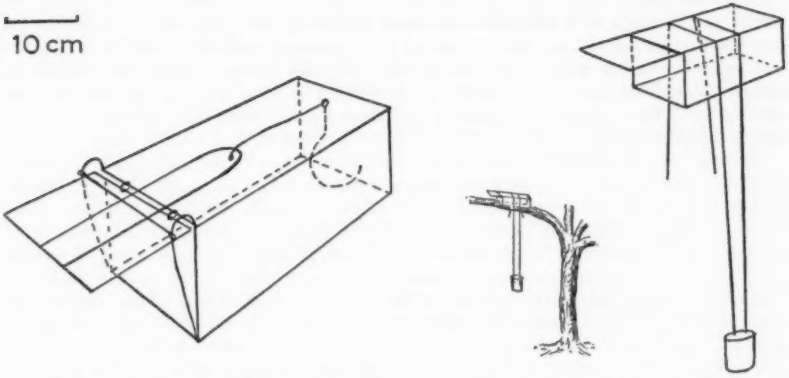


FIG. 1.—Trap as used for rats (at left) and as modified for use for tree squirrels.

This trap is first set and then put in position by balancing it over the branch of a tree. The counterweight proves effective for holding it in position even when a large animal is struggling in the cage. It can be put over branches up to 2 m. or so from the ground by hand, or up to nearly 10 m. by using a long pole, rather like a "lamp-lighter's pole," consisting of a bamboo at the top of which a wire hook is fixed. The hook is passed through the mesh of the set trap which can then be put on fairly high branches. Owing to the unsteadiness of the pole, however, it has not been found practicable to work higher than about 7 m. with this device. By climbing the tree, however, one may set the trap at greater heights.

A satisfactory bait for squirrels has been found in small unripe bananas. The bait hook in these traps is an arc of about 8 cm. diameter and the sharp end of this hook is passed through one end of the banana and then through the other so that the banana stays on the hook without swinging. It ripens on the hook but remains firm for several days. The efficiency of this trap is indicated by the captures of tree squirrels, *Callosciurus notatus*, in Malayan forests. In tree sets baited with banana, 1,940 trap-nights netted 89 individuals; in ground sets baited with banana, 970 trap-nights netted 14 individuals; and in ground sets baited with sweet potato, 2,910 trap-nights netted 3 individuals.—JOHN L. HARRISON, *Institute for Medical Research, Malaya (now at the Queensland Institute of Medical Research, Australia).* *Received 1 December 1958.*

PLAN NOW to combine your vacation with the 1960 Annual Meeting of the Society at Tacoma, Washington, 20–22 June. Details on page 157, this issue.

REVIEWS

Handley, Charles O., Jr. A Revision of American Bats of the Genera Euderma and Plecotus. Proc. U.S. Nat. Mus., vol. 110, pp. 95–246, 27 figs. 3 September 1959.

It is a common course of procedure for a person to gather much material relating to a particular subject, to study his material enough to arrive at major conclusions, and then because the excitement of discovery is past, and because further work on the subject becomes drudgery, to lay the material aside without systematizing and publishing the results. Mammalogy as a discipline may have tended to follow that same course for the past ten years; anyhow, now that specimens have been accumulated in sufficient numbers to warrant taxonomic revisions of several taxa, old 19th century classifications based on scanty material too often are accepted as correct, or as adequate, by students who are working on different groups of mammals, and those students commonly content themselves with learning only how a mammal lives, how far it wanders, and what it does.

Handley's account avoids the shortcoming mentioned above; he deals also, and princ'pally, with what the mammal is. A large proportion of the specimens now available were assayed by him and the results are rewarding. Most of the mammals concerned have long been known as *Corynorhinus* but prove to be referable instead to the genus *Plecotus*. Four species of *Plecotus* live in North America. For two of these the application of specific names is shown long to have been reversed; the correct name of the western species is *Plecotus* (*Corynorhinus*) *townsendii* and of the eastern *Plecotus* (*Corynorhinus*) *rafinesquii*. *Plecotus* (*Corynorhinus*) *mexicanus*, Handley thinks, is a species and not merely a subspecies of *P.* (*C.*) *townsendii*. The fourth species is *Plecotus* (*Idionycteris*) *phyllotis*. For the first time a figure of a complete cranium of a spotted bat, *Euderma maculatum*, is provided. External details of the muzzles of the subgenera *Corynorhinus* and *Plecotus* are figured as also are the details of the external ears of those two subgenera and of the subgenus *Idionycteris*. Extinct as well as living species are considered. The taxonomic material is presented without duplication in the place where it belongs because the account proceeds in correct systematic order from genera to subgenera to species to subspecies.

Probably someone higher in the administrative hierarchy of the National Museum than Handley is to blame for the lack of a date of publication on his taxonomic paper. Handley probably is responsible for the unfortunate lack of borders, scales, and indications of latitude and longitude on figures 10–15, 18, 19, 22–24, and 27. His statement (p. 108) that "On the basis of dental, osteological, and external features, it appears that *Euderma* and *Plecotus* should stand between *Myotis* and *Pipistrellus* in the classification of the Chiroptera" can hardly be correct if Hall and Dalquest (Univ. Kansas Publ., Mus. Nat. Hist., 1: 585–586, 20 January 1950) were correct in earlier pointing out that *Myotis* may not be generically separable from *Pipistrellus* inasmuch as the only constant difference between some American species of the two genera is subequal (in *Pipistrellus*) *versus* unequal (in *Myotis*) upper incisor teeth. Keying names in synonymies to the terminal "Literature Cited" frustrates the reader and is contrary to the usual practice in revisions. Omission of parentheses on names of authorities for specific and subspecific names that the author combines with generic names different than those used when the specific and subspecific names first were proposed is misleading and contrary to the recommendation of the International Commission on Zoological Nomenclature. Assignment of three fossil species to the genus *Plecotus* (pp. 137–140, and 208) and subsequent listing of them under the generic names *Vespertilio* and *Corynorhinus* (pp. 208–210) is a taxonomic infelicity. Many previously recorded occurrences are relegated to a category of unnecessarily doubtful status by being listed under the heading of "The following records probably refer to this form"; from most of the localities listed, Handley could have examined specimens by visiting the collections in which the specimens are contained or by obtaining them on loan.

Handley summarizes natural history information, estimates relationships of species, and presents the data to support his contention that *Plecotus mexicanus* is specifically distinct

from any other named kind of the genus *Plecotus*. Studies corresponding to Handley's are much needed and now that large numbers of specimens have been prepared and deposited in collections it is to be hoped that his example will influence other mammalogists to make corresponding studies of other genera and to publish the results of those studies. —E. Raymond Hall.

Goodrich, Edwin S. Studies on the Structure and Development of Vertebrates. 2 Vols. Dover Publications, Inc., New York. Pp. lxix + 837, 754 illus. Paperback reprint, 5 January 1958. Price, $5.00.

It is hardly necessary to review the contents of a book so widely known as Goodrich's Structure and Development of Vertebrates. Dover publishers are to be commended for their choice of this irreplaceable reference on vertebrate morphology for republication in an inexpensive paperback edition. This edition will be especially valuable to those young teachers of anatomy who otherwise might never expect to be fortunate enough to include this work in their personal libraries.

The reprinting is issued in two parts. The first includes the initial eight chapters of the original and, except for the introductory material, deals exclusively with the skeleton. The second part, of six chapters, deals with the soft anatomy and also contains the bibliography for both parts which runs to 1,186 titles.

There is a sizable list of *errata et corrigenda* in each volume, and the user would do well to enter these in the text before using it too seriously as a reference. This is perhaps the price one must pay for the low cost of the set. The illustrations seem to be printed somewhat darker than in the original, but the contrast is not great enough to cause any of the details to be obscured, except in a few of the halftones. The quality of the paper is good, and the binding is sewn, making it fit for rebinding in buckram, which the contents justly deserve.—Bryan P. Glass.

Dasmann, Raymond F. Environmental Conservation. John Wiley & Sons, Inc., New York. Pp. xi + 307, 153 figs. 13 February 1959. Price, $6.50.

Designed as a textbook for a one-semester course in conservation at the lower division college level, this carefully composed volume seems destined for a far larger audience. Written by an ecologist with a special interest in wildlife management, it considers the history of human populations—their prodigal past, dreary present, and precarious future—in relation to the conservation of natural resources. The twelve chapters sketch the broad background of the subject. Nonrenewable and renewable resources are defined, and the point is stressed that their good management involves wise use with the avoidance of waste, on the one hand, and practices resulting in a sustained yield, on the other. The major biotic regions of the world are described; problems relating to agricultural lands and soil conservation, use and abuse of water resources, forests and man, livestock and range lands, aquatic and terrestrial wildlife are discussed.

This reviewer was particularly impressed by the thoroughly readable account of "Man's Record on the Earth" in the longest chapter of all. Man emerges as a rather puny character, running headlong to his own destruction. Endowed as he is with superior mental capacity, he still is unable to conduct his affairs rationally. His future may well depend on how well he manages his natural resources. And in this connection, "Not only is it important to guarantee food, shelter, and mechanical devices for future populations because these are basic, but also we must plan to provide those qualities, less easily defined in economic terms, that enrich life —space to live in, wild lands to roam in, wild scenery to admire and wild animals to watch, study, or hunt."

A chapter devoted to "Land and Wild Animal Life" tells the story of the depletion of the early wildlife in this country, leading to laws as early as the 17th century designed to preserve game. The philosophy of restoration of wildlife followed later, with both California and New

Hampshire establishing fish and game commissions in 1878, and with Michigan, Minnesota and Wisconsin hiring permanent salaried game wardens in 1887. In 1896, the federal government entered the field of game protection with the establishment of the Division [later Bureau] of Biological Survey. The familiar story of our progress to ecological thinking is illustrated by the stories of the Kaibab deer herd and of the Wells Gray Park caribou herd. Finally, the wildlife specialist, with emphasis on habitat management and population dynamics, replaced the earlier advocates of simple preservation and restocking. We have made much progress over the centuries, and in many ways North America has led the way in wildlife conservation. But we are still far from knowing all the answers. "There is an increasing feeling also that wild land and wildlife may be strangely important for the preservation of man himself. With the unbridled growth of technological civilization, with its regimentation, specialization, and tensions, the pressures on the human spirit grow more intense. Until a more sane way of life can be achieved, man needs a refuge, a place for escape from artificiality and confinement, where he can come to grips with his own still-primitive self. So long as wild places and animals are preserved, a sanctuary for man also remains."

Some may feel that the author is unduly pessimistic over the problem of human populations. True, we have the examples of China and India, largely denuded by poor agricultural practices. We observe that the present world population of 2,666,000,000±, averaging out at about 13 acres of land per person, will by 1980 increase by nearly 50 per cent (United Nations estimate) if the present trend continues. And we know that at least two-thirds of the world's people today are undernourished. But overpopulations and the need for Lebensraum are nothing new; and the Four Horsemen are still at work. We seem unaware that "this is *one world* from many viewpoints but remains *many worlds* economically." Moreover, our present sources of energy will soon be inadequate if most regions of the world attempt to industrialize, as seems likely. No sure escape from this dilemma is indicated, though "environmental conservation, combined with self-imposed limitations on human population growth," is suggested as a possible solution. It is consoling to note the author's concern with the use of natural resources for both the material and spiritual enrichment of life for man. And many will heartily agree that "In any planning for the future of man on this earth, we must also plan for the wild land and wild creatures which have been a part of his heritage and which must remain a part of his life—if such life is to have much meaning."—RICHARD H. MANVILLE.

RECENT LITERATURE

(Prepared by the Committee on Bibliography)

[Beginning with this issue, reprints of the section on "Recent Literature" will no longer be available.]

ABADIE, JACQUES, JACQUES BARBEAU, AND YVES COPPENS. Une faune de vertébrés villafranchiens au Tchad. Comptes Rendus Acad. Sci., Paris, 248 (23): 3328–3330. 8 June 1959.

ALF, RAYMOND M. Mammal footprints from the Avawatz Formation, California. Bull. Southern California Acad. Sci., 58 (1): 1–7. 11 May 1959.

ANDERSON, SYDNEY. Mammals of the Grand Mesa, Colorado. Univ. Kansas Publ., Mus. Nat. Hist., 9 (16): 405–414. 20 May 1959.

ANONYMOUS. Gray whales. Nat. Hist. Mus. Bull., San Diego, no. 318. 1 April 1959.

ANONYMOUS. Good catch at British Columbia. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (5): 240–244, map. May 1959.

ANONYMOUS. Capture d'une genette en Seine-et-Oise. Mammalia, Paris, 23 (2): 240–241. June 1959.

ARATA, ANDREW A. Ecology of muskrats in strip-mine ponds in southern Illinois. Jour. Wildlife Management, 23 (2): 177–186, illus. April 1959.

ARMENTA, J. Hallazgo de un artefacto asociado con mamut, en el Valle de Puebla. Publ. Inst. Nac. Anthro. Hist. Mexico, 7: 1–30, illus. 1959.

ASHTON, E. H., AND H. G. VEVERS. The numbers of exhibits, births and deaths in the menagerie at Regent's Park: 1835–1957, and in Whipsnade Park: 1931–1957. Proc. Zool. Soc. London, 132 (3): 489–515. 29 May 1959.

BANNIKOV, ANDREJ G. Zur Biologie des Kulans *Equus hemionus* Pallas. Zeitschr. Säugetierk., Berlin, 23 (3–4): 157–168, pl. 16. 1958.

BARNETT, C. H., AND O. J. LEWIS. The evolution of some traction epiphyses in birds and mammals. Jour. Anat., London, 92 (4): 568–579. October 1958.

BECK, J. R., S. B. OSGOOD, AND MELVIN D. SMITH (editors). The Oregon meadow mouse irruption of 1957–1958. Federal Cooperative Extension Service, Oregon State College, Corvallis, pp. 1–88, illus. 1959. (Included articles: Foreword, by F. E. Price; Economic and control aspects, by J. D. Vertrees; Biological and control aspects, by Donald A. Spencer; Influences of the poisoning program on wildlife, by James Mohr; Predation by hawks, owls, and gulls, by John J. Craighead; Epizootiologic aspects, by L. Kartman, F. M. Prince, and S. F. Quan; Physical features of the environment, by N. J. Peterson; Epidemiological aspects, by S. B. Osgood, M. A. Holmes, V. Runte, and G. R. Brandon; Mouse disease studies, by W. L. Jellison, J. F. Bell, and C. R. Owen; Investigation of wildlife animals for leptospirosis, by Robert W. Menges and Mildred M. Galton.)

BELL, J. FREDERICK, WILLIAM L. JELLISON, CORA R. OWEN, AND CARL L. LARSON. Applicability of the Ascoli test to epizootic tularemia in wild rodents. Jour. Wildlife Management, 23 (2): 238–240. April 1959.

BELL, J. FREDERICK. Transmission of rabies to laboratory animals by bite of a naturally infected bat. Science, 129 (3361): 1490–1491. 29 May 1959.

BENDELL, J. F. Food as a control of a population of white-footed mice, *Peromyscus leucopus noveboracensis* Fischer. Canadian Jour. Zool., 37 (2): 173–209. April 1959.

BENNETT, DOROTHEA, AND L. C. DUNN. Effects on embryonic development of a group of genetically similar lethal alleles derived from different populations of wild house mice. Jour. Morphol., Philadelphia, 103 (1): 135–158. July 1958.

BLAIR, W. FRANK, AND T. E. KENNERLY, JR. Effects of X-irradiation on a natural population of the wood-mouse (Peromyscus leucopus). Texas Jour. Sci., 11 (2): 137–149. June 1959.

BLANC, G., AND F. PETTER. Présence au Maroc de l'écureuil terrestre du Sénégal *Xerus erythropus*. Mammalia, Paris, 23 (2): 239–240. June 1959.

BODENHEIMER, F. S. A remark on vole outbreaks. Bull. Res. Council Israel, B8 (2): 97–98. June 1959.

BÖGLI, BRUNO. Das tubo-uterine Ventil beim Goldhamster. Rev. Suisse Zool., 66 (5): 211–227. April 1959.

BOLWIG, NIELS. Observations and thoughts on the evolution of facial mimic. Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 60–69, illus. 1959.

BOLWIG, NIELS. Further observations on the physiological and behavioural characteristics of small animals in the southern Kalahari. Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 70–76. 1959.

BOONE AND CROCKETT CLUB. Records of North American big game. Henry Holt & Co., New York, pp. xvi + 264, illus. October 1958.

Borowski, Stanislaw. Variations in density of coat during the life cycle of *Sorex araneus araneus* L. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 286–289. 30 May 1959.

Bovbjerg, Richard V. Mammalian predation on mussels. Proc. Iowa Acad. Sci., 63: 737–740. 1956.

Broek, Elisabeth van den, and P. Wensvoort. On parasites of seals from the Dutch coastal waters and their pathogenity. Säugetierk. Mitteil., 7 (2): 58–62. 1 May 1959.

Brosset, A., and B. Caubère. Contribution a l'étude écologique des chiroptères de l'ouest de la France et du Bassin Parisien. Mammalia, Paris, 23 (2): 180–238. June 1959.

Brown, S. G. Whales observed in the Atlantic Ocean, notes on their distribution. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (6): 289–308. June 1959.

Bryan, E. H., Jr. Notes on the geography and natural history of Wake Island. Atoll Research Bull., Pacific Science Board, 66: 1–22. 15 May 1959.

Burdelov, A. S., and O. B. Rossinskaya. On the range of Selevinia betpakdalensis Belos. et Bazh. (1938) and on some pecularities of its ecology. Zool. Zhurnal, 38 (6): 942–944. June 1959. (In Russian, with English summary.)

Butler, H. An early blastocyst of the lesser bush baby (*Galago senegalensis senegalensis*); a preliminary account. Jour. Anat., London, 93 (2): 257–261. April 1959.

Butler, P. M., and J. R. E. Mills. A contribution to the odontology of *Oreopithecus*. Bull. British Mus. (Nat. Hist.), Geol., 4 (1): 1–26, illus. April 1959.

Cadenat, J., and M. Doutre. Notes sur les delphinidés ouest-africains. V.—Sur un *Prodelphinus* à long bec capturé au large des côtes du Sénégal *Prodelphinus longirostris* (Gray) 1828? Bull. Inst. Français Afrique Noire, ser. A, 21 (2): 787–798. April 1959.

Cadenat, J., and A. Lassarat. Notes sur les delphinidés ouest-africains. IV.—Sur un *Prodelphinus* indéterminé de Côte d'Ivoire. Bull. Inst. Français Afrique Noire, ser. A, 21 (2): 777–786. April 1959.

Caia, Lan-po, and Ju-Kang Woo. Fossil human skull base of late Paleolithic stage from Chilinshan, Leipin District, Kwangsi, China. Vertebrata Palasiatica, 3 (1): 37–39, illus. March 1959.

Chia, Lan-po. Report on the excavation of *Sinanthropus* site in 1958. Vertebrata Palasiatica, 3 (1): 41–45, illus. March 1959.

Chow, Minchen, and C. C. Hu. A new species of *Parabrontops* from the Oligocene of Lunan, Yunnan. Acta Paleo. Sinica, 7 (2): 85–88, illus. April 1959. (New: *P. lunanensis*).

Chow, Minchen, and Ben-shun Chow. Villafranchian mammals from Lingyi, S. W. Shansi. Acta Paleo. Sinica, 7 (2): 89–97, illus. April 1959. (Summary in English.)

Cleland, K. W., and Lord Rothschild. The bandicoot spermatozoon: an electron microscope study of the tail. Proc. Royal Soc., Cambridge, ser. B, 150 (938): 24–42. January 1959.

Cockrum, E. Lendell, and Ellen Ordway. Bats of the Chiricahua Mountains, Cochise County, Arizona. Amer. Mus. Novitates, New York, 1938: 1–35, illus. 5 June 1959.

Dalimier, Paul. Les chabins, hybrides chèvres-moutons. Säugetierk. Mitteil., 7 (2): 49–52. 1 May 1959.

Dathe, H. Gedanken über einen Affenpark. Zool. Garten, 22 (4–6): 238–239. 1959.

Dawbin, W. H. New Zealand and South Pacific whale marking and recoveries to the end of 1958. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (5): 213–238, illus. May 1959.

DAWBIN, W. H. Evidence on growth-rates obtained from two marked humpback whales. Nature, London, 183 (4677): 1749–1750. 20 June 1959.

DEHNEL, AUGUST. Mammals research institute of the Polish Academy of Sciences, Bialowieza. Acta Theriologica, Polska Akad. Nauk. Bialowieza, 2 (14): 300–307. 30 May 1959.

DE KOCK, L. The arterial vessels of the neck in the pilot-whale and the porpoise in relation to the carotid body. Acta Anatomica, Basel, 36 (4): 274–292. 1959.

DIDIER, ROBERT. Note sur les os péniens des rongeurs collectés au Pérou par J. Dorst. Mammalia, Paris, 23 (2): 172–179, illus. June 1959.

DIETRICH, W. O. *Hemionus* Pallas im Pleistozän von Berlin. Vertebrata Palasiatica, 3 (1): 13–22, illus. March 1959.

DIXON, KEITH L. Spatial organization in a population of Nelson pocket mice. Southwestern Naturalist, 3: 107–113. 1 June 1959.

DODDS, DONALD G. Feeding and growth of a captive moose calf. Jour. Wildlife Management, 23 (2): 231–232. April 1959.

DOWNING, ROBERT L., AND CHARLES M. MARSHALL. A new plastic tape marker for birds and mammals. Jour. Wildlife Management, 23 (2): 223–224, illus. April 1959.

DOWNS, THEODORE, HILDEGARDE HOWARD, THOMAS CLEMENTS, AND GERALD A. SMITH. Quaternary animals from Schuiling Cave in the Mojave Desert, California. Contrib. Sci. Los Angeles County Mus., 29: 1–21, illus. 14 April 1959.

DULIĆ, BEATRICA. Zweiter Nachweis der Bechsteinfledermaus, *Myotis bechsteini* Kuhl, 1818 für Jugoslawien. Säugetierk. Mitteil., 7 (2): 75. 1 May 1959.

DURRANT, STEPHEN D., AND NOWLAN K. DEAN. Mammals of Glen Canyon, *in* Ecological Studies of the flora and fauna in Glen Canyon. Univ. Utah Anthro. Papers, no. 40 (Glen Canyon ser. no. 7), pp. 73–103. June 1959.

EKMAN, SVEN. Über den nordeuropäischen Vielfrass (*Gulo gulo* L.). Zeitschr. Säugetierk., Berlin, 23 (3–4): 169–181. 1958. (With comment by Peter Krott.)

ELOFF, F. C. Observations on the migration and habits of the antelopes of the Kalahari Gemsbok Park. Parts I & II. Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 1–51, illus. 1959.

ESTES, RICHARD D. A visit to our first takin. Animal Kingdom, New York Zool. Soc., 62 (2): 37–42, illus. April 1959.

FARRAND, RICHARD L., G. EDGAR FOLK, JR., AND MARVIN L. RIEDESEL. Types of mammalian hibernation. Proc. Iowa Acad. Sci., 63: 724–728. 1956.

FINLAYSON, H. H. On *Bettongia cuniculus* Ogilby, 1838 (Marsupialia). Trans. Royal Soc. South Australia, 82: 283–290. April 1959.

FINLAYSON, H. H. Subfossil Potoroinae (Marsupialia) from South Australia. Trans. Royal Soc. South Australia, 82: 291–300. April 1959.

FLEAY, ROSEMARY. Orphanage for Australian animals. Animal Kingdom, New York Zool. Soc., 62 (2): 43–46, illus. April 1959.

FLYGER, V. F. A comparison of methods for estimating squirrel populations. Jour. Wildlife Management, 23 (2): 220–223. April 1959.

FUJIHARA, MITIKO. Crossing experiments between the Japanese wild mouse and the European albino mouse (First report). Mem. Biol. Soc. Ritumeikan Univ., Kyoto, pp. 9–17, illus. 1958. (In English.)

FUJIHARA, MITIKO. Crossing experiments between the Japanese wild mouse and the European albino mouse (Second report). Mem. Biol. Soc. Ritumeikan Univ., Kyoto, pp. 18–31. 1958. (In Japanese, with English summary.)

FUJIHARA, MITIKO. On the growth of the body weight of the hybrid offsprings between the Japanese wild mouse and the European albino mouse. Mem. Biol. Soc. Ritumeikan Univ., Kyoto, pp. 32–45. 1958. (In Japanese, with English summary.)

GILBERT, PAUL, AND JOHN HARRIS. How far do deer travel? Colorado Outdoors, 8 (2): 18–20. March–April 1959.

GRAHAM, RICHARD. Additions to the Pleistocene fauna of Samwel Cave, California. I. Canis lupus and Canis latrans. Cave Studies, Publication of Cave Research Associates, no. 10, pp. 54–67, pl. 1. 30 April 1959.

GREENHALL, ARTHUR M. The ecological rôle of Trinidad bats, especially the vampire, and bat rabies. Veterinary Record, 71 (10): 188–190. 7 March 1959.

GROMOVA, VERA. Gigantic rhinoceroses. Trudy Paleo. Inst., Akad. Nauk SSSR, 71: 1–164, illus. 1959. (In Russian.)

GUILER, ERIC R. The occurrence of the jerboa mouse, Ascopharynx cervinus (Gould), in Tasmania. Australian Jour. Sci., 21 (7): 220–221. March–April 1959.

HALL, E. RAYMOND. Geographic distribution of contemporary organisms. Introduction. Zoogeography, Amer. Assoc. Adv. Sci., pp. 371–373. December 1958.

HALL, E. RAYMOND, AND KEITH R. KELSON. The mammals of North America. Ronald Press Co., New York, vol. 1, pp. i–xxx + 1–546, index 1–79; vol. 2, pp. i–viii + 547–1083, index (repeated) 1–79, illus. 31 March 1959.

HAMILTON, W. J., JR. Foods of mink in New York. New York Fish & Game Jour., 6 (1): 77–85. January 1959.

HAMPSON, CY. Tree-trunk apartment. Blue Jay, Saskatchewan Nat. Hist. Soc., 17 (2): 47–49. June 1959. (Tenants include weasel, photo.)

HARRISON, DAVID L. A new subspecies of lesser long-winged bat Miniopterus minor Peters, 1867, from the Comoro Islands. Durban Mus. Nov., 5 (15): 191–196. 30 April 1959. (New: *M. m. griveaudi.*)

HARTMAN, F. A. Notes on the adrenal of the sloth. Anat. Record, 133 (1): 105–113. January 1959.

HARVEY, ELMER B. Placentation in Ochotonidae. Amer. Jour. Anat., 104 (1): 61–86. January 1959.

HARVEY, E. B. Tubal ovum in Ochotonidae. (Lagomorpha). Anat. Record, 132 (1): 113–119. September 1958.

HERSHER, L., A. V. MOORE, AND J. B. RICHMOND. Effect of post partum separation of mother and kid on maternal care in the domestic goat. Science, 128 (3335): 1342–1343. 28 November 1958.

HERSHKOVITZ, PHILIP. The scientific names of the species of capuchin monkeys (*Cebus* Erxleben). Proc. Biol. Soc. Washington, 72: 1–4. 7 April 1959.

HERSHKOVITZ, PHILIP. Two new genera of South American rodents (Cricetinae). Proc. Biol. Soc. Washington, 72: 5–10. 7 April 1959. (New: *Wiedomys, Pseudoryzomys.*)

HERSHKOVITZ, PHILIP. A new species of South American brocket, genus *Mazama* (Cervidae). Proc. Biol. Soc. Washington, 72: 45–54, illus. 1 May 1959. (New: *M. chunyi.*)

HILL, J. P., AND K. M. WATSON. The early development of the brain in marsupials. Preliminary communication. Jour. Anat., London, 92 (4): 493–497. October 1958.

HOFFMAN, R. A., AND M. X. ZARROW. Seasonal changes in the basophilic cells of the pituitary gland of the ground squirrel (Citellus tridecemlineatus). Anat. Record, Philadelphia, 131 (4): 727–736. August 1958.

HOFFMEISTER, DONALD F., AND CARL O. MOHR. Fieldbook of Illinois mammals. Illinois Nat. Hist. Survey Div., Urbana, Manual No. 4, pp. xii + 233, illus. June 1957.

HOFFMEISTER, DONALD F. A new spotted ground squirrel from Mexico. Proc. Biol. Soc. Washington, 72: 37–38. 1 May 1959. (New: *Citellus spilosoma ammophilus.*)

HOLM, JOHN L., AND ÅGE JONSGÅRD. Occurrence of the sperm whale in the Antarctic and the possible influence of the moon. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (4): 161–182. April 1959.

HOLMES, R. L., AND S. ZUCKERMAN. The blood supply of the hypophysis in *Macaca mulatta.* Jour. Anat., London, 93 (1): 1–8. January 1959.

HOOIJER, D. A. A vertebrate fauna from the Pleistocene of Celebes. Proc. XVth Internat. Congr. Zool., London, sec. 5, pp. 444–445. 1959. (Abstract.)

HOOIJER, D. A. Faked rhinoceros horns. Bijdragen Taal-, Land- en Volkerkunde, 115 (1): [2 pp., 1 pl.]. 1959.

HUDSON, PAUL. Fetal recoveries in mule deer. Jour. Wildlife Management, 23 (2): 234–235. April 1959.

INGLES, LLOYD G. A quantitative study of mountain beaver activity. Amer. Midland Nat., 61 (2): 419–423. 1959.

INGLES, LLOYD G. Notas acerca de los mamíferos mexicanos. Anales Inst. Biol., Mexico City, 29 (1–2): 379–408. 31 March 1959.

JAHN, LAURENCE R. Highway mortality as an index of deer-population change. Jour. Wildlife Management, 23 (2): 187–197. April 1959.

JANES, DONALD W. Home range and movements of the eastern cottontail in Kansas. Univ. Kansas Publ., Mus. Nat. Hist., 10 (7): 553–572, illus. 4 May 1959.

JONG, C. DE. Ratten en ziekte van Weil. Rat en Muis, Wageningen, Netherlands, no. 2, pp. 3–9. June 1959. (Rats and Weil's disease.)

JOUFFROY, F. K. Un crâne subfossile de macaque du Pléistocène du Viet Nam. Bull. Mus. Nat. Hist. Nat., Paris, ser. 2, 31: 209–216. April 1959. (New: *Macaca speciosa subfossilis.*)

KEENER, JOHN M. Wisconsin's predator control program. Wisconsin Conservation Bull., 24 (6): 3–10. June 1959.

KEITH, JAMES O., RICHARD M. HANSEN, AND A. LORIN WARD. Effect of 2,4-D on abundance and foods of pocket gophers. Jour. Wildlife Management, 23 (2): 137–145, illus. April 1959.

KELLOGG, REMINGTON. Description of the skull of *Pomatodelphis inaequalis* Allen. Bull. Mus. Comp. Zool., 121 (1): 1–26, illus. May 1959.

KHAJURIA, H. Notes on the systematics of three leaf monkeys in the collection of the Indian Museum (Zool. Surv.). Records Indian Mus., 52 (1): 95–100. March 1954.

KHAJURIA, H. Catalogue of mammals in the Indian Museum (Zool. Surv.). II. Primates: Cercopithecidae. Records Indian Mus., 52 (1): 101–128. March 1954.

KHAJURIA, H. Catalogue of mammals in the Zoological Survey of India. IV. Primates: Prosimii, Tarsioidea and Platyrrhine. Records Indian Mus., 53 (1–2): 223–250. March–June 1955.

KNUDSEN, GEORGE J. The case for the beaver pond. Wisconsin Conservation Bull., 24 (4): 3–6. April 1959.

KORSCHGEN, LEROY J. Food habits of the red fox in Missouri. Jour. Wildlife Management, 23 (2): 168–176. April 1959.

KREBSER, WERNER. Die Bestandsaufnahme des Fischotters (*Lutra l. lutra*) in der Schweiz, 1951–1953. Säugetierk. Mitteil., 7 (2): 67–75. 1 May 1959.

KRYLTSOV, A. I. Materials on the moult of mouse-like rodents. Part 2. The moult in various representatives of the subfamily of voles. Zool. Zhurnal, 38 (5): 745–755. May 1959. (In Russian, with English summary.)

KRZANOWSKI, ADAM. Behaviour of bats during the total solar eclipse in Poland on June 30th, 1954. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 281–283. 30 May 1959.

KRZANOWSKI, ADAM. Daytime activity of Nyctalus noctula Schreb. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 283–284. 30 May 1959.

KRZANOWSKI, ADAM. Unusual summer hiding-place of bats. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 284–285. 30 May 1959.

KRZANOWSKI, ADAM. Interesting tawny specimen of the long-eared bat (*Plecotus auritus* L.). Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 285. 30 May 1959.

KULIK, I. L. On the longevity of Rhombomys opimus Licht. in nature. Zool. Zhurnal, 38 (6): 944–947. June 1959.

KURODA, NAGAMICHI, AND TERUAKI UCHIDA. A new form of *Crocidura suaveolens* (Pallas)

from Okinoshima, off northern Kyushu, in the Sea of Japan. Annot. Zool. Japonenses, Tokyo, 32 (1): 43–46. March 1959. (New: *C. s. okinoshimae.*)

LAYNE, JAMES N. Growth and development of the eastern harvest mouse, *Reithrodontomys humulis*. Bull. Florida State Mus., Biol. Sci., 4 (2): 61–82. 27 April 1959.

LECHLEITNER, R. R. Some parasites and infectious diseases in a black-tailed jackrabbit population in the Sacramento Valley, California. California Fish & Game, 45 (2): 83–91. April 1959.

LEISTNER, O. A. Notes on the vegetation of the Kalahari Gemsbok National Park with special reference to its influence on the distribution of antelopes. Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 128–151. 1959.

LINDER, RAYMOND L., AND GEORGE O. HENDRICKSON. Use of rearing cover by Mearns cottontail. Proc. Iowa Acad. Sci., 63: 732–736. 1956.

LINHART, SAMUEL B. Sex ratios of the red fox and gray fox in New York. New York Fish & Game Jour., 6 (1): 116–117. January 1959.

LOCKIE, J. D. The estimation of the food of foxes. Jour. Wildlife Management, 23 (2): 224–227. April 1959.

LORD, REXFORD D., JR. A method for measuring mortality of cottontail rabbits in winter. Jour. Wildlife Management, 23 (2): 241–243. April 1959.

LOVELESS, CHARLES M., AND RICHARD F. HARLOW. Canine teeth in Florida white-tailed deer (*Odocoileus virginianus seminolus* Goldman and Kellogg). Quart. Jour. Florida Acad. Sci., 22 (1): 76–77. March 1959.

MADDY, KEITH T., E. LENDELL COCKRUM, AND H. GILBERT CRECELIUS. Bat rabies in Arizona. Arizona Medicine, 15 (5): 344–349. May 1958.

MAISEL, ALBERT Q. The riddle of the "abominable snowman." Reader's Digest, 74 (445): 55–60. May 1959.

MALDONADO-KOERDELL, MANUEL. Sobre un rinoceronte fosil de Sinaloa, Mexico. Riv. Soc. Mex. Hist. Nat., 15 (1–4): 141–146, illus. December 1954.

MALDONADO-KOERDELL, MANUEL. Sobre un craneo de *Aenocyon dirus* (Leidy) del Pleistocene Superior de Tequixquiac, Mexico. Anales Inst. Nac. Anthro. Hist. Mexico, 7 (1953): 51–58, illus. 1955.

MALDONADO-KOERDELL, MANUEL. Sobre dos molares de *Paraelephas columbi* (Falconer) del Pleistocene Superior de Tequixquiac, Mexico. Anales Inst. Nac. Anthro. Hist. Mexico, 7 (1953): 59–63, illus. 1955.

MALDONADO-KOERDELL, MANUEL. Nuevos hallazgos de antilocapridos en el Pleistoceno Superior de Tequixquiac, Mexico. Acta. Zool. Mexicana, 1 (7): 1–7, illus. December 1955.

MALADONADO-KOERDELL, MANUEL. Recientes adelantos en la taxonomia de los primates de America del Sur. Miscellanea Paul Rivet, pp. 345–352. 1958.

MANARO, ARTHUR J. Extrusive incisor growth in the rodent genera *Geomys, Peromyscus,* and *Sigmodon*. Quart. Jour. Florida Acad. Sci., 22 (1): 25–31. March 1959.

MANN F., GUILLERMO. Reproducción de *Dromiciops australis* (Marsupialia, Didelphydae). Investig. Zool. Chilenas, Santiago, 4: 209–213. 30 August 1958.

MANNING, T. H., AND A. H. MACPHERSON. The mammals of Banks Island. Technical Paper Arctic Inst. North Amer., 2: 1–74. August 1958. (New: *Lepus arcticus banksicola, Lemmus trimucronatus phaiocephalus.*)

MATTHEW, WILLIAM DILLER, AND CARLOS DE PAULA COUTO. The Cuban edentates. Bull. Amer. Mus. Nat. Hist., 117 (1): 1–56, illus. 20 April 1959. (New: *Megalocnus ursulus.*)

MATTHEY, ROBERT. Formules chromosomiques de *Muridae* et de *Spalacidae*. La question du polymorphisme chromosomique chez les mammifères. Rev. Suisse Zool., 66 (5): 175–209. April 1959.

MCCARLEY, W. H. A study of the dynamics of a population of Peromyscus gossypinus and

P. nuttalli subjected to the effects of X-irradiation. Amer. Midland Nat., 61 (2): 447–469. 1959.

McDowell, Robert D., and Harold W. Pillsbury. Wildlife damage to crops in the United States. Jour. Wildlife Management, 23 (2): 240–241. April 1959.

McGrew, Paul O. The geology and paleontology of the Elk Mountain and Tabernacle Butte area, Wyoming. Bull. Amer. Mus. Nat. Hist., 117 (3): 117–176, pls. 50–57, map. 18 May 1959. (With the collaboration of Jack E. Berman, Max K. Hecht, John M. Hummel, George Gaylord Simpson, and Albert E. Wood. New mammals: *Peratherium knighti* McGrew, *Diacodon edenensis* McGrew, *D. bacchanalis* McGrew, *Shoshonius? laurae* Simpson, *Leptotomus parvus* Simpson, *Microparamys* Wood, *M. wyomingensis* Wood, *Thisbemys* Wood, *T. corrugatus* Wood.)

McKenna, Malcolm C., and George Gaylord Simpson. A new insectivore from the Middle Eocene of Tabernacle Butte, Wyoming. Amer. Mus. Novitates, 1952: 1–12. 26 June 1959. (New: *Scenopagus*; *S. mcgrewi.*)

Meester, J. Adaptation of *Crocidura hirta* Peters to variation in moisture conditions in southern Africa. Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 173–179. 1959.

Merwe, N. J. van der. Die wildehond (*Lycaon pictus*). Koedoe, Jour. Sci. Research, Nat. Parks Union of South Africa, Pretoria, 2: 87–93. 1959.

Milstead, William W., and Donald W. Tinkle. Notes on the porcupine (*Erethizon dorsatum*) in Texas. Southwestern Naturalist, 2: 237. 1 June 1959.

Moore, Joseph Curtis. New genera of East Indian squirrels. Amer. Mus. Novitates, 1914: 1–5. 22 October 1958. (New: *Sundasciurus, Aletesciurus, Exilisciurus.*)

Moore, Joseph Curtis. A new subgenus and new species of squirrel from Borneo. Amer. Mus. Novitates, 1944: 1–10. 17 June 1959. (New: *Hessonoglyphotes*; *Glyphotes* (*H.*) *canalvus.*)

Mooser-Barendum, Oswaldo. La fauna "Cedazo" del Pleistoceno en Aguascalientes. Anales Inst. Biol., Mexico, 29 (1–2): 409–452, illus. 31 March 1959. (New: *Onager zoyatalis*; *O. arellanoi*; *O. hibbardi*; *O. oviedoi*; *Asinus aguascalientensis*; *Equus parastylidens.*)

Morrison, Peter. Body temperatures in some Australian mammals. I. Chiroptera. Biol. Bull., 116 (3): 484–497. June 1959.

Mottl, M. Neue Säugetierfunde aus dem Jungtertiär der Steiermark. Mitteil. Mus. Bergbau, Geol. & Technik, Landesmus. Joanneum, 19: 1–41, illus. 1958.

Münch, Hans. Zur Ökologie und Psychologie von *Marmota m. marmota*. Zeitschr. Säugetierk., Berlin, 23 (3–4): 129–138, pl. 13. 1958.

Myers, Betty J. Stomach contents of harp seals (*Phoca gröenlandica*) from the Magdalen Islands, Quebec. Canadian Jour. Zool., 37 (3): 378. June 1959.

Nagy, Eugen. Berichtigung zur Szunyoghys "Systematischer Revision des ungarländischen Schakals, gleichzeitig eine Bermerkung über das Rohrwolf-Problem." Säugetierk. Mitteil., 7 (2): 62–64, illus. 1 May 1959.

National Geographic Society. Book of dogs. National Geographic Society, Washington, D.C., pp. 430, illus. 1958.

Nero, R. W. Winter records of bats in Saskatchewan. Blue Jay, 17 (2): 78, 84. June 1959.

Olsen, Peter F. Dental patterns as age indicators in muskrats. Jour. Wildlife Management, 23 (2): 228–231, illus. April 1959.

Olsen, Stanley J. The baculum of the Miocene carnivore *Amphicyon*. Jour. Paleontol., 33 (3): 449–450, pl. 67. May 1959.

Olsen, Stanley J. The middle ear of the Miocene mustelid *Leptarctus*. Jour. Paleontol., 33 (3): 451–452, pl. 68. May 1959.

Olsen, Stanley J. Fossil mammals of Florida. Special Publ. Florida Geol. Surv. 6: 1–74, illus. 1959.

PEACOCK, J. L., AND C. M. ROGERS. Gestation period and twinning in chimpanzees. Science, 129 (3354): 959. 10 April 1959.

PERROTTA, CARMIE A. Fetal membranes of the Canadian porcupine, Erethizon dorsatum. Amer. Jour. Anat., 104 (1): 35–60. January 1959.

PETTER, F. Un nouveau rongeur de Madagascar (Nesomyinae): *Macrotarsomys ingens* nov. sp. Mammalia, Paris, 23 (2): 139–148, illus. June 1959.

PILLERI, G. Ontogenese und Cerebralisation beim Biber (*Castor canadensis*, Kuhl). Rev. Suisse Zool., 66 (4): 165–174. April 1959.

PIMLOTT, DOUGLAS H., AND H. W. MOSSMAN. A macroscopic ovary-sectioning method. Jour. Wildlife Management, 23 (2): 232–233. April 1959.

POURNELLE, GEORGE H. Born to be a clown. Zoonooz, Zool. Soc. San Diego, 32 (4): 3–4, illus. April, 1959. (Sloth bear.)

PRAKASH, ISHWAR. Behaviour of certain mammals towards snakes. Indian Psychological Bull., 3 (2): 49–51. September 1958.

PRAKASH, ISHWAR. Extinct and vanishing mammals from the desert of Rajasthan and the problem of their preservation. Indian Forester, 84 (10): 642–645. October 1958.

PRAKASH, ISHWAR. Destruction of vegetation by desert animals in Rajasthan. Indian Forester, 85 (4): 251–253. April 1959.

PREMVATI. Studies on Strongyloides of primates. V. Synonymy of the species in monkeys and apes. Canadian Jour. Zool., 37 (1): 75–82. February 1959.

PRUITT, WILLIAM O., JR. Microclimates and local distribution of small mammals on the George Reserve, Michigan. Misc. Publ. Mus. Zool. Univ. Michigan, 109: 1–27. 17 June 1959.

RAKOV, N. V. A new trap for catching Ellobius talpinus Pall. Zool. Zhurnal, 38 (5): 783–785. May 1959. (In Russian, with English summary.)

RAUN, GERALD G. Terrestrial and aquatic vertebrates of a moist, relict area in central Texas. Texas Jour. Sci., 11 (2): 158–171. June 1959.

RAUN, GERALD G., AND JAMES K. BAKER. Some observations of Texas cave bats. Southwestern Naturalist, 3: 102–106. 1 June 1959.

RIDDLE, JAMES M. Animal intruders in the Zoo. Zoonooz, Zool. Soc. San Diego, 32 (4): 10–14, illus. April 1959.

ROTH, ERIKA, AND HARALD H. ROTH. Mitteilung über die künstliche Aufzucht eines Bennett-Känguruhs (*Macropus bennetti* Gould). Zool. Garten, 22 (1–3): 233–234, 1958; 22 (4–6): 235–238, 1959.

RUCH, THEODORE C. Diseases of laboratory primates. W. B. Saunders Co., Philadelphia, pp. xxvi + 600, illus. 1959. (Part One of "The Handbook of the Primates," to be issued in four parts.)

RUDD, ROBERT L. Rodent control by aircraft and pesticidal hazards to wildlife. California Vector Views, State Dept. Public Health, 6 (4): 23–25. May–June 1959.

RUSSELL, W. L., LAINE BRAUCH RUSSELL, AND JOSEPHINE S. GOWER. Exceptional inheritance of a sex-linked gene in the mouse explain on the basis that the X/O sex chromosome constitution is female. Proc. Nat. Acad. Sci., 45 (4): 554–560. April 1959.

SALEZ, M. Notes sur la distribution et la biologie du cerf de Barbarie (*Cervus elaphus barbarus*). Mammalia, Paris, 23 (2): 133–138, pl. 10. June 1959.

SCHÄUFFELEN, OTMAR. Zur Anatomie des Chinchillaschädels. Veröff. Zool. Staatss. München, 5: 189–232. April 1959.

SCHLOETH, ROBERT. Das Scharren bei Rind und Pferd. Zeitschr. Säugetierk., Berlin, 23 (3–4): 139–148, pl. 14. 1958.

SCHLOETH, ROBERT. Beobachtungen über die Reaktionen von Affen gegenüber schlangenähnlichen Erscheinungen. Säugetierk. Mitteil., 7 (2): 64–66. 1 May 1959.

SCHNEIDER, KARL MAX. Zum Zahndurchbruch des Löwen (*Panthera leo*) nebst Bemerkun-

gen über das Zahnen einiger anderer Grosskatzen und der Hauskatze (*Felis catus*). Zool. Garten, 22 (4–6): 240–361, illus. 1959.

SCHOLANDER, P. F. Wave-riding dolphins: How do they do it? Science, 129 (3356): 1085–1087. 24 April 1959.

SCHULTZ, ADOLPH H. Acrocephalo-oligodactylism in a wild chimpanzee. Jour. Anat., London, 92 (4): 568–579. October 1958.

SCIBOR, JULIAN. Der Wisent (*Bison bonasus* L.) im Urwald von Bialowieza. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 296–299. 30 May 1959.

SERGEANT, D. F. Age determination in odontocete whales from dentinal growth layers. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (6): 273–288, illus. June 1959.

SETZER, HENRY W. The mustelids of Egypt. Jour. Egyptian Public Health Assoc., 33 (6): 199–204. 8 April 1959. (New: *Poecilictis libyca alexandrae.*)

SETZER, HENRY W. The gerbils of Egypt. Jour. Egyptian Public Health Assoc., 33 (6): 205–227. 8 April 1959. (New: *Gerbillus campestris haymani, G. c. wassifi, G. henleyi makrami, G. kaiseri, G. perpallidus, G. pyramidum elbaensis.*)

SHARMA, D. R., AND S. SIVARAM. On the hyoid region of the Indian gerbils. Mammalia, Paris, 23 (2): 149–167. June 1959.

SHEPPE, WALTER A., JR. Notes on the distribution and habitats of mammals in the Pacific northwest. Murrelet, 40 (1): 1–4. January–April 1959.

SIDOROWICZ, JERZY. Some notes on the edible dormouse (*Glis glis* L.) in Poland. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 292–295. 30 May 1959.

SIDOROWICZ, JERZY. Dark phase of the squirrel (*Sciurus vulgaris fuscoater* Altum) in Bialowieza. Acta Theriologica, Polska Acad. Nauk, Bialowieza, 2 (14): 295. 30 May 1959. (In Polish.)

SIMON, NOEL. Wildlife challenges in East Africa. Animal Kingdom, New York Zool. Soc., 62 (2): 50–55, illus. April 1959.

SIMPSON, GEORGE GAYLORD. Note on biometry and systematics. Bull. Amer. Mus. Nat. Hist., 117 (1): 51–54, illus. 20 April 1959. (*In* W. D. Matthew and C. de Paulo Couto, "The Cuban edentates.")

SIMPSON, GEORGE GAYLORD. A new Middle Eocene edentate from Wyoming. Amer. Mus. Novitates, 1950: 1–8. 17 June 1959. (New: *Tetrapassalus; T. mckennai.*)

SKOCZEN, STANISLAW. Determination of the sex of moles (*Talpa europaea* L.) by means of their external features. Acta Theriologica, Polska Akad. Nauk, Bialowieza, 2 (14): 290–292. 30 May 1959.

SLES', I. S. Acclimatization of the antelope Taurotracus oryx Pall. in the Askania-Nova zoo. Zool. Zhurnal, 38 (6): 920–930. June 1959. (In Russian, with English summary.)

SOKOLOV, I. I. On the postcranial skeleton and the outward appearance of *Spirocerus kiakhtensis* M. Pavlova. Vertebrata Palasiatica, 3 (1): 23–32, illus. March 1959.

STEIN, GEORG H. W. Eine neue Farbmutante des Maulwurfs (Talpa europaea L.). Zeitschr. Säugetierk., Berlin, 23 (3–4): 198–199. 1958.

STEINBACHER, GEORG. Trächtigkeitsdauer beim Weissbartgnu (*Connochaetes taurinus*). Säugetierk. Mitteil., 7 (2): 75. 1 May 1959.

STIEHM, HOWARD. The antelope. Colorado Outdoors, 8 (2): 16–17. March–April 1959. (*Antilocapra.*)

STIRTON, R. A. Time, life, and man. The fossil record. John Wiley & Sons, New York, pp. xi + 558, illus. 1959.

STÖLZER, EBERHARD. Beiträge zur Kenntnis der Seitendrüsen des Syrischen Goldhamsters (*Mesocricetus auratus* Waterhouse). Zeitschr. Säugetierk., Berlin, 23 (3–4): 182–197, pl. 17. 1958.

SULIMSKI, ANDRZEJ. Pliocene Insectivores from Weze. Acta Palaeontol. Pol., 4 (2): 119–173, illus. 1959. (New: *Erinaceus samsonowiczi; Blarinoides, B. mariae; Neomys soriculoides; Suncus zelceus.*)

SVIRIDENKO, P. A. The growth and development of the vole Clethrionomys glareolus Schreb. Zool. Zhurnal, 38 (5): 756–766. May 1959. (In Russian, with English summary.)

SWYNNERTON, G. H. A tentative grouping of the species of the genus Crocidura Wagler, 1832 (Insectivora: Soricidae) occurring in Africa. Durban Mus. Nov., 5 (14): 185–189. 30 April 1959.

TAMSITT, J. R. Abundance of the Palo Duro mouse *Peromyscus comanche* during 1949–1956. Southwestern Naturalist, 3: 234–236. 1 June 1959.

TANAKA, RYO. A criticism on some examples offering a kill-efficiency by the mark-and-release census of pre- and post-poisoning vole populations. Bull. Kochi Women's Univ., Ser. Nat. Sci., 7 (3): 7–13. March 1959.

TREICHEL, GEORGE. Africa and our wildlife heritage. Animal Kingdom, New York Zool. Soc., 61 (6): 162–168; 62 (1): 22–28. December 1958; February 1959.

TRUMLER, EBERHARD. Einige Beobachtungen beim Spiel jugendlicher Steppenelefanten, *Loxodonta africana knochenhaueri* Matschie, 1900. Säugetierk. Mitteil., 7 (2): 52–58. 1 May 1959.

VAN GELDER, RICHARD G. A taxonomic revision of the spotted skunks (genus *Spilogale*). Bull. Amer. Mus. Nat. Hist., 117 (5): 229–392. 15 June 1959.

VERSCHUREN, JACQUES. Exploration du Parc National de la Garamba. Mission H. de Saeger. Écologie et biologie des grands mammifères (primates, carnivores, ongulés). Inst. Parcs Nat. Congo Belge, Brussels, fasc 9, pp. 225, pls. 2. 1958.

VIETINGHOFF-RIESCH, FRHR. v. Aussergewöhnlich früher Wurf eines Siebenschläfers (*Glis glis*). Zeitschr. Säugetierk., Berlin, 23 (3–4): 198. 1958.

VLADYKOV, VADIM D. Études sur les mammifères aquatiques. IV. Nourriture du Marsouin Blanc ou Béluga (*Delphinapterus leucas*) du fleuve Saint-Laurent. Cont. Inst. Biol. Univ. Montreal, no. 19, pp. 1–160, illus. 1947.

VOGEL, S. Fledermausblumen in Sudamerika. Österreichische Botanische Zeitschrift, 104: 491–530, illus. 25 March 1958.

VOLF, JIRI. La reproduction des genettes au zoo de Prague. Mammalia, Paris, 23 (2): 168–171. June 1959.

WEGNER, RICHARD N. Über eine Trochleabildung unter dem Scheitelkamm des Seebären (*Otaria byronia* de Blainville 1820). Zeitschr. Säugetierk., Berlin, 23 (3–4): 149–156, pl. 15. 1958.

WELLS, L. H. The Quaternary giant hartebeests of South Africa. South African Jour. Sci., 55 (5): 123–128. May 1959.

WELSHONS, W. J., AND LAINE BRAUCH RUSSELL. The Y-chromosome as the bearer of male determining factors in the mouse. Proc. Nat. Acad. Sci., 45 (4): 560–566. April 1959.

WOOD, ALBERT E., AND BRYAN PATTERSON. The rodents of the Deseadan Oligocene of Patagonia and the beginnings of South American rodent evolution. Bull. Mus. Comp. Zool., 120 (3): 281–428. May 1959 (New: *Deseadomys, D. arambourgi, D. loomisi, Chubutomys simpsoni, Protosteiromys, P. asmodeophilus.*)

YATSENKO, E. N. Reproduction of the vole Prometheomys schaposchnikovi Satunin. Zool. Zhurnal, 38 (6): 916–919. June 1959. (In Russian, with English summary.)

YOUATT, W. G., AND A. W. ERICKSON. Some effects of sodium pentobarbital anesthesia on juvenile black bears. Jour. Wildlife Management, 23 (2): 243–244. April 1959.

ZICCARDI, FERNANDINO. Zebra senza criniera dell'Oltregiuba. (An unmaned zebra from the Juba River.) Suppl. Ricerche Zool. Applicata alla Caccia, Lab. Zool. Applicata alla Caccia, Univ. Bologna, 2 (10): 293–299, 2 pls. June 1959. (New: *Zebra burchelli isabella.*)

ZIMMERMANN, KLAUS. Taschenbuch unserer wildlebenden Säugetiere. Urania Verlag, Leipzig, pp. 169, illus. 1959.

ZUKOWSKY, LUDWIG. Erfolgreiche Aufzucht von zwei Seehundsäuglingen im Münsterschen Zoo. Zool. Garten, 22 (4–6): 361–363. 1959.

COMMENTS AND NEWS

NOTICE OF ANNUAL MEETING

The Fortieth Annual Meeting of the Society will be held at Pacific Lutheran College, Tacoma, Washington, 20–22 June 1960. Co-host will be the University of Puget Sound. The Directors' meeting will be at 8:00 PM on 19 June. Open sessions will begin on the morning of 20 June. The co-chairmen of the local committee are Burton T. Ostenson and Murray L. Johnson.

Titles for papers should be submitted to the Secretary-Treasurer, Dr. Bryan P. Glass. The deadline is 1 May, but it is urged that titles, estimates of time and equipment needed be sent in at an early date. Papers to be considered for an honorarium and resolutions proposed for action should be submitted early (see below).

Recommended housing is in the new Pacific Lutheran College dormitories. Rooms have twin beds; some have three. Families, couples and singles will be housed in separate wings. Charges will be $2.00 per person. Check-in time will be 7:00 to 11:00 PM Sunday. Meals will be served in the College Union. Breakfasts and lunches for three days will be $5.25. Dinners will be handled separately. Meal charges for children under 12 will be somewhat less. Make reservations in advance by writing to Dr. Burton T. Ostenson, Pacific Lutheran College, Tacoma 44, Washington. No deposit is required.

Camping and trailer sites will be available at Bresemann's Park near Spanaway Lake, 2 miles south of the College. Motels within a mile of the College include the Orchard Hill Motel, 14209 Pacific Avenue, and the Miller Motel, 11104 Pacific Avenue; rates are $6.00 to $7.50 for double. The Winthrop Hotel is located at 773 Broadway in downtown Tacoma, about 8 miles away; rates are $6.50 to $11.00 (single) and $9.00 to $16.00 (double). Numerous other accommodations are available a few miles to the west on U.S. Highway 99 near Fort Lewis and McChord Air Base. For reservations, write directly to the hotel or motel of your choice.

Tacoma is a community of about 150,000 people located near the southern end of Puget Sound, about 30 miles south of Seattle. It is served by major bus and railroad lines; Seattle-Tacoma International Airport is about 20 miles from the city center. Pacific Lutheran College is located at the southern limits of Tacoma, about 8 miles from the city center, on the Mt. Rainier highway. The co-host, Puget Sound University, is about 1 mile west from the city center.

Within three hours' drive from Tacoma one may visit the Pacific Ocean beaches, the rain forests of the Olympic National Park, the Cascade range dominated by Mt. Rainier, or the arid sagebrush region east of the Cascades. The alpine areas of the Olympic Mountains may be reached by two roads. The Cascades are crossed by a number of major highways, and Mt. Rainier National Park high country is less than two hours' drive from the Pacific Lutheran campus. The high country is probably better after the meeting because of heavy snow packs at these altitudes. The weather is usually pleasant, though rains may occur at any time; the weather is more likely to be settled in late June and July than earlier in the year. Oregon, Idaho, Montana and British Columbia all provide exceptional vacation areas within a day's drive of Tacoma. For those who wish to visit Alaska, many daily flights will bring one to Anchorage (6-hour trip, $165.00 round-trip base fare) or Fairbanks (6-hour trip, $198.00 round-trip base fare). From these centers almost any spot in Alaska can be reached by frequent plane service.

RESOLUTIONS

Members having resolutions intended for action by the Society at its next annual meeting are urged to submit them to the Resolutions Committee at the earliest opportunity. The committee is anxious to submit the proposals to the members prior to the meeting but can

do so only if they receive such proposals at an early date. The deadline of 1 May 1960 has been set. Proposed resolutions should be sent to the Committee Chairman, Dr. Keith R. Kelson, National Science Foundation, Washington 25, D.C.

HONORARIA

Two honoraria are available each year for young mammalogists who have not obtained the Ph.D. degree. These honoraria carry a stipend of $100.00 each to help defray the expenses of travel to the annual meeting for the presentation of the paper. Our next meetings will be held in Tacoma, Washington, 20–22 June 1960. Entries should be submitted to Dr. Stephen D. Durrant, Department of Zoology, University of Utah, Salt Lake City, Utah, before 1 April 1960.

CONSOLIDATION OF MAGAZINES

The forthcoming consolidation of two distinguished magazines, *Natural History*, published by The American Museum of Natural History in New York since 1900, and *Nature Magazine*, published by the American Nature Association in Washington since 1923, has recently been announced. Many of the popular features of both publications will be continued, in a considerably larger magazine but at no increase in the $5.00 annual subscription price that has been charged for each. The new magazine will be published in New York under the direction of John Purcell; Richard W. Westwood will serve as a contributing editor.

MATTERS OF STYLE

In attempting to keep pace with the times, as well as maintain good taste in the pages of the JOURNAL, it becomes necessary to alter our style a trifle from time to time. Readers will note in this issue the use of the international date system which is fast gaining favor, i.e., 20 February 1960, 25 December, or May 1950. Where space is at a premium, as in some tables, the longer months may be abbreviated or may be replaced by Roman numerals, e.g., 4 VII 1776.

The sections of Literature Cited should be used only for published works. Articles "in press" should be included only if they are expected to be out in time to complete the citations in galley proofs. Unpublished theses, data *in litt.*, and conversations are not properly literature; if essential, reference to them may be made parenthetically in the text only.

There is a growing sentiment for an initial Abstract (or Synopsis) of feature articles, to replace the terminal Summary. It serves as a useful preview to the entire article, summarizes the contents and conclusions, points to new information, and indicates the relevance of the material. It should be completely intelligible and self-explanatory, aimed at readers who have some knowledge of the field but have not read the paper. No abstract should exceed 225 words; most should be considerably shorter. It will be appreciated if authors of major articles submit abstracts with their manuscripts in future.

Unnecessarily large photographs and figures intended for publication are cumbersome to handle, expensive to mail, and a nuisance generally. Furthermore, no useful purpose is served by submitting illustrative material larger than 8½ × 11 inches. Authors are urged *not* to submit such oversize materials to accompany manuscripts for publication.—ED.

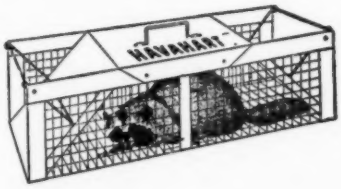
ACTA THERIOLOGICA

Since 1958 the journal *Acta Theriologica*, previously published by the Zoological Institute of the Polish Academy of Sciences, has been under the aegis of the Mammals Research Institute, Polish Academy of Sciences, in Białowieża. Volume 3 was recently completed. The journal carries most Polish works dealing with wild mammals, as well as works on mammals hitherto intended for the Annales Universitatis Mariae Curie-Skłodowska, Lublin; works of foreign authors may also be published. The various papers are printed as separate parts, distributed twice a year on an exchange basis. They are printed mainly in the Congress languages (including English), or in Polish with comprehensive foreign-language summaries.

DEATHS REPORTED

Hiram B. D. Blauvelt, Life Member, 16 October 1957
James D. Bump, 22 November 1959
Robert M. Hedrick, July 1957
Arthur W. Henn, May 1959
Marcel L. Legrand, October 1959
William R. Rawlings, 9 July 1959
Albert C. Rogers, Charter Member, 31 July 1959
Amon R. Shearer, 16 January 1959

HAVAHART HUMANE ANIMAL TRAPS



The *Allcock Manufacturing Company* has a large variety of humane animal traps. They have many sizes of live traps for those who are interested in catching the animals unharmed. The HAVAHART TRAPPING BOOKLET will be sent free of charge to anyone who requests it from the *Allcock Manufacturing Company, Ossining, New York.* HAVAHART traps have been used successfully by many who have been doing live-trapping experiments on small mammals. Write for the free booklet today.

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the Editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Notices will be continued in each issue unless cancellation is received a month before publication or unless specified in original order. Bills will be rendered by the Secretary-Treasurer following publication.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

FOR SALE—Live desert rodents. Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

FOR SALE—*The Wolf in North American History* (Caxton, 1946), now out of print, at $2.15 per copy postpaid in U.S., from author, Stanley P. Young, Room 58A, U.S. National Museum, Washington 25, D.C.

FOR SALE—Bailey's *The Mammals of Virginia*, 432 pp., 99 illus., 1946. Originally $5.00. Few copies left, $2.50 each. John W. Bailey, 27 Willway Rd., Richmond 26, Va.

ALL-PETS MAGAZINE is written for hobbyists, breeders, fanciers and people engaged in pets for profit; covers all unusual livestock kept as pets, plus aquaria, cage and aviary birds, cats and dogs; subscription $3.50 per year. Manuscripts solicited from ASM members. Established 25 years, circulation world-wide, 80 pages and up monthly. We also publish books on pet livestock; some 80 titles now. National distributors of some 350 books on pets. Write for free book circular to Frank Dittrich, 139 Darling Place, Fond du Lac, Wisconsin.